THE ENGINEER

A Seven-Day Journal

Scarce Metals

The Minister of Supply, Mr. Strauss, made a statement in the House of Commons last Friday morning about the grave shortage of nickel, tungsten and molybdenum and, consequently, of alloy steels. He said that everything possible was being done to obtain greater supplies but there was immediate need to make savings in the civil use of these metals to provide for the very heavy requirements of the rearmament programme. To make it possible in respect of nickel, the Minister continued, certain other nickel uses must be cut immediately. Nickel supplies had not fallen but the heavy defence demand coming on top of a rising civilian demand had produced an acute shortage. As an emergency measure, therefore, as from May 1st, the amount of nickel supplied for stainless steel production would be cut to 70 per cent of the 1950 level and supplies of nickel anodes for plating would be cut to 50 per cent of the 1950 level. Those cuts would be followed by the prohibition of less essential uses of nickel. Mr. Strauss went on to explain that supplies of molybdenum, for which we were entirely dependent on the U.S.A., were far below the 1950 level and there was a sharply increased demand on account of the defence programme. If the rearmament demand had to be met in full from the current rate of supplies there would be hardly anything left for civil production. Supplies of tungsten were also precarious and to supplement imports the mining of tungsten ore was to be started again in Devonshire. There was little scope for prohibiting inessential end uses of either molybdenum or tungsten. Technical committees of the iron and steel industry had been set up to examine urgently what economies could be made in the use of nickel, molybdenum and tungsten in modification of alloy steel specifications and the Minister said that he felt sure they would have the co-operation of the alloy steel using industries. The committees would also be of great assistance in the examination of the specifications of alloy steels for the rearmament programme to find what further economies could safely be made there. But, he added, all those measures would have to be supplemented as soon as possible by closer control of the distribution of nickel, tungsten, molybdenum and the alloy steels.

Proposed Land Drainage Legislation

Early in 1947 the Central Advisory Water Committee appointed a sub-committee, under the chairmanship of Lieut.-Colonel Sir Arthur Heneage, to consider proposals and make recommendations for amending and modernising the law relating to land drainage. The sub-committee's report, which is unanimous, was published last week by H.M. Stationery Office. During the course of its enquiry, the committee made special visits to study land drainage problems in Lincolnshire, Essex, the Thames Valley, Somerset and North Wales. The report points out that, at present, river boards are responsible for the principal watercourses of their area, owners and occupiers being responsible for farm ditches. Outside the internal drainage districts, however, no authority is directly responsible for the intermediate channels, which are estimated to average more than 1000 yards per square mile of countryside. As a result, they are frequently neglected, food production is thereby lost and towns and villages are subject to flooding. The report recommends the extension of the works jurisdiction of river boards to all channels, large and small, in their areas, apart from drains, which would remain the responsibility of internal drainage boards, and farm ditches. To effect this, county and borough councils would lose the general powers which they now possess and owners and occupiers would be required to keep farm ditches in good condition and free from obstruction. But, for the first time in land drainage history, definite responsibility would be arranged for every stream in England and Wales from its source to the sea. River boards, of course, would have to decide where each channel ceased to be a farm ditch and became a watercourse and, for deciding that issue, the subcommittee has suggested certain practical tests. The report proposes a new source of revenue from a drainage charge on agricultural land, estimated to raise over £1,000,000 a year, and Exchequer equalisation grants in special cases when a river board's resources do not match the need for works within its area. Another matter discussed in the report is the local flooding, which may be caused by sewage and storm water discharges from new towns and large housing estates, proposals being made for developers to contribute towards the cost of remedying such flooding.

Loss of H.M. Submarine "Affray"

At the time of going to press last week there was still hope that H.M. Submarine "Affray," which submerged on Monday night, April 16th, and failed to surface on Tuesday morning, would be located and her crew rescued. It is therefore with very deep regret that we record that in spite of an intensive search by frigates, destroyers, submarines and aircraft, it has proved impossible to establish contact with the submarine and that the passing of time has made it evident that all hope of rescuing the crew must be abandoned. The "Affray," an "A"-Class submarine, was completed in 1946. She has a length overall of 281ft 8in, a displacement of 1120 tons on the surface and 1620 tons when submerged, and ten torpedo tubes. She is driven by twin-eight-cylinder diesel engines of 4300 total b.h.p., to give a surface speed of 18 knots, while electric motors of 1250 h.p. maintain a speed of 8 knots. With a number of submarine officers and marine other ranks on training courses included in the crew, there was a total of seventy-five men on board when the "Affray" put to sea to carry out a practice war patrol while on passage from Portsmouth to Falmouth. Initially there was a possibility that orders to report daily had been misinterpreted, but the slight chance that this was so rapidly vanished as time made an accident an increasing probability. A puzzling feature of the accident has been the lack of response to signals after the submarine "Sea Devil" had picked up what was thought to be a message from "Affray," the absence of marker buoys and the fact that no use was made of the escape apparatus. The search continues in an effort to locate and salvage the submarine and to establish the cause of the disaster; meanwhile all submarines of the class have been ordered to stay in port.

The First Year of the Public Health Engineering Course

The new post-graduate course in public health engineering, organised jointly by the Imperial College of Science and Technology and the London School of Hygiene and Tropical Medicine, was started in October, 1950, and a report of the first year's work has now been issued. The number of applications and enquiries received from many parts of the world, it is stated, indicates that there is a widespread need for the education of engineers on the broad lines which are being followed. At the City and Guilds College a laboratory has been equipped for the examination of water and sewage and for experiments in treatment processes, and a public health engineering library has been built up; both facilities were made possible by grants from the Rockefeller Foundation. A number of departments of Imperial College have co-operated in giving the students courses of instruction in a variety of subjects, some of which are normally regarded as outside the scope of engineering, but which are of vital importance to engineers concerned with problems affecting public health. These courses have included a general introduction to biology, with special reference to the insect vectors of disease, bacteriology, statistics, the chemistry of water and sewage and the geology of water supply. Laboratory work, demonstrations and films have been used in connection with several of these courses. Lectures on water supply and treatment and sewerage and sewage treatment have been supplemented by design problems, laboratory experiments, visits to works and the operation of a pilot sewage treatment plant. Other subjects include food hygiene, refuse disposal and rodent control. At the London School of Hygiene students have followed courses in occupational health, with many visits to industrial and other centres, air hygiene, epidemiology, tropical hygiene and public health and local government, and have had an insight into the medical man's approach to questions of hygiene. Practical work on a number of sanitation problems will be carried out during the summer at the Imperial College field station at Silwood Park, near Ascot. The report states that the new course has had a favourable reception in the press and among the engineering and medical professions and the sponsors of the scheme have received every encouragement to carry on with the work and to extend and improve the course in the future. An important aspect of the enrolment of students, noted in the report, is the question of finance. There is no doubt, it is said, that many more British students would take a course of this nature if they could find the money to keep them for an extra year at the university. In most cases unless a grant or scholarship is forthcoming to support the student for a post-graduate year, he is obliged to leave the university and take a paid job.

New Power Stations at Ince and Portishead

The British Electricity Authority has received the consent of the Ministry of Fuel and Power to the establishment of a 240MW power station at Ince, Cheshire, which will provide power primarily for the atomic energy plant at Capenhurst, and will be Britain's first semi-outdoor station. Generally the main portion of the boiler section will stand in the open air but the operating area around the combustion chamber and steam drums will be totally enclosed, thus giving the operating staff complete protection from the weather. The authorisation for the establishment of the Ince station covers the installation of four 60MW turbo-alternator sets, four boiler units, each of an evaporative capacity of 550,000 lb an hour and four cooling towers. Consent for the establishment of a new 360 MW power station at Portishead, near Bristol, has been received by the British Electricity Authority from the Ministry of Fuel and Power. The new power station will be built as an addition to the existing 248·15MW station and will be known as Portishead "B." The consent from the Minister authorises the installation of six 60MW turbo-alternator sets and twelve boilers, each of a steam evaporative capacity of 300,000 lb an hour.

British Industries Fair

No. I

ON Monday next, the 1951 British Industries Fair will open at Castle Bromwich, Birmingham, and at Olympia and Earls Court in London, and it will be open daily until Friday, May 11th. This year the products of nearly 3000 firms in ninety industries will be displayed and the total space occupied will be well over a million square feet.

The engineering section of the Fair, as in previous years, is again mainly concentrated at Castle Bromwich, and in this and succeeding issues we propose to give particulars of some of the new plant and equipment which will be shown. A very large proportion of the exhibits in the engineering sections have appeared in previous exhibitions and have been dealt with in the technical press. Although a fairly wide field of industry is covered many important branches such as machine tools, motor-cars, aircraft, engines, &c., do not participate in the British Industries Fair, as they mainly confine themselves to their own specialised exhibitions. For this reason, although the Fair gives a fairly good picture of the range and diversity of British engineering and allied industries, it does not include a number of the leading exporting industries.

As was the case last year, the Federation of Manufacturers of Contractors' Plant has taken a keen interest in the Fair, and in the 70,000 square feet of outdoor space occupied by its member firms at Castle Bromwich a very comprehensive range of construction equipment will be seen.

British Oxygen Company, Ltd.

A representative display of heavy and light-duty oxy-acetylene welding and cutting equipment is to be shown upon the stand of the British Oxygen Company, Ltd., of Bridgewater House, Cleveland Row, London, S.W.1.

A piece of equipment of interest amongst the company's machine cutting plant is the plate edge preparation unit fitted with the "Multifloat" attachment. This equipment is designed for preparing the edges of plates for welding by the simultaneous sizing and cutting of bevels and nose on the plate edges. With four of these machines running on a suitable track all four sides of a plate can be prepared at the same time. With the "Multifloat" attachment, curves can be cut on one or more of the plate edges whilst the other cuts are in progress.

In bevel cutting for welding preparation on plate edges, the oxygen jet is projected at an angle to the plate surface and even slight variations in the distance of the nozzle from the plate surface can cause considerable irregularity of the cut edge.

On the plate edge preparation machine exhibited the cutting nozzles are carried on a floating arm which is free to move up and down. In it the weight of the arm carrying the nozzles is supported by a roller which rides directly on the plate surface adjacent to the cut so that the distance between the nozzles and the plate surface remains constant, even when cutting an undulating plate. The roller is protected from the heat of the cutting nozzles by a jet of compressed air which cools it and also serves a useful purpose in blowing away loose scale in the roller's path.

The arm of the machine is carried on a variable-speed tractor which moves along a standard track at a predetermined speed. The tractor track width is 10in and the machine can be arranged to run either on the flanges of a standard R.S.J. or a suitable track can be built up. The track can consist of a single straight length, an L-shape, enabling two machines to be utilised, or four tracks may be set up to form a rectangle. Using four machines this last arrangement enables all four edges of the plate to be cut simultaneously, and the makers say that equipment of this kind is now in regular use in many shipyards.

The tractor used with the "Multifloat" attachment is basically the same. On top of the tractor, and mounted at right angles to the track, there is a sliding arm, the end of which carries the floating link mechanism, which, in turn, supports the cutting nozzle and the plate riding roller. With the attachment, which is illustrated in Fig. 1, movement of the sliding arm is effected by a flexible steel wire riding over jockey pulleys and supporting a weight suspended in a tube on the opposite side of the machine from the cutting head. The arm is adjustable for extension and may also be locked for straight cuts. When unlocked the action of the weight automatically moves the arm inwards over the plate. A bracket carrying two horizontal rollers at the foot of the cutting head is fitted, and during curve cutting these rollers bear against a steel guide strip laid on the surface of the plates. The strip is kept in the desired position by means of several small permanent magnets, spaced at about 10in intervals, and the strip is sufficiently flexible to enable curves of reasonably small radius to be followed accurately. This magnet method of fixing the guide strip enables small adjustments to be made with speed and accuracy. Control of arm movement by means of a weight ensures that the rollers bear upon the guide strip with the same pressure irrespective of the amount the arm is extended.

The cutting head is also arranged to swivel on its vertical axis so that the nozzles are at all times cutting on a track true to the radius of the required curve.

In the standard arrangement the machine is fitted with three cutting nozzles so that a nose and top and bottom bevels on a plate edge can be cut simultaneously, but the set-up can be varied according to requirements, and single square cuts or nose and one bevel only may be cut without altering the equipment.

Stothert and Pitt, Ltd.

Most of the contractors' plant to be seen upon the stand taken by Stothert and Pitt, Ltd., of Bath, has already been described in The Engineer. A recent addition to the firm's range of vibrating rollers which has not been shown before will have a wide range of application.

This new 10 cwt tandem vibrating roller is illustrated in Fig. 2. In this unit traction and vibration are applied to the front roll and steering and braking are effected through the rear roll. The driver sits on a comfortable sprung saddle astride the main frame girder connecting the two rolls. Rolls 28in wide and 22in diameter are fitted to this machine, the weight on the front vibrating roll being 7 cwt and on the rear roll 3 cwt.

A 2¾ h.p., air-cooled, four-stroke, petrol engine is enclosed in a rigid sheet metal housing over the front roll, and provides the motive power for high-frequency vibration of the roll and for traction. Power is transmitted to the vibrator through a friction clutch controlled by a hand lever. The traction drive is transmitted through a gearbox containing reversing friction clutches, spur reduction and change-speed gears, and change-speed clutches. There are two forward and two reverse travelling speeds of ⅝ and 1¼ miles an hour, and the direction of travel can be quickly reversed without shock through a convenient hand lever.

The yoke and frame within which the rear wheel is carried on heavy ball bearings,

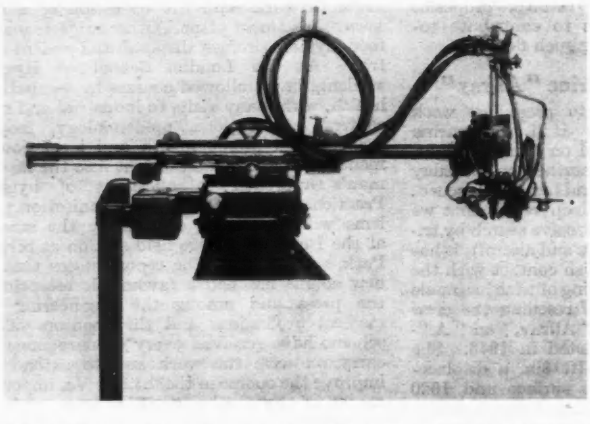

Fig. 1—Plate Edge Preparation Machine—British Oxygen

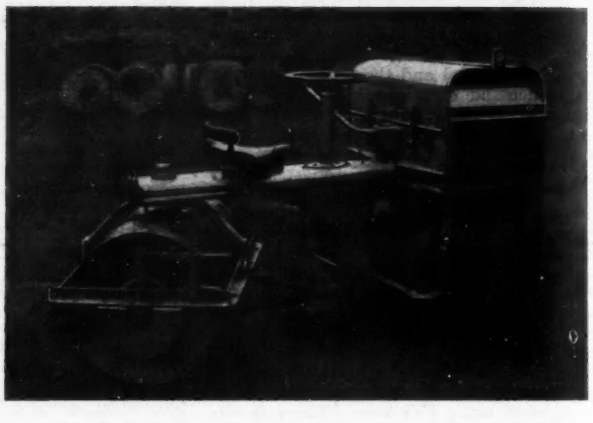

Fig. 2—Tandem Vibrating 10-cwt Roller—Stothert and Pitt

swivels in roller bearings in the main frame member, and the machine is steered through chains and sprockets by an automobile type steering wheel. A hand brake operates on the rear roll of the machine.

Girdlestone Pumps, Ltd.

A recent addition to the range of pumps made by Girdlestone Pumps, Ltd., of Woodbridge, Suffolk, is a duplex diaphragm pump which is illustrated in Fig. 3. This new unit consists essentially of two of the company's standard "DMF 100" pump bodies arranged horizontally, opposite one another, and operated from a common shaft and eccentric. With this arrangement a considerably increased output is obtained. The units are made by the firm with cast iron, gun-metal and cast iron ebonite-lined bodies and contact parts to handle various kinds of corrosive and abrasive liquids.

Fig. 3—Duplex Diaphragm Pump—Girdlestone

In the duplex pump a motor mounted at one end of the assembly drives the roller-bearing-mounted shaft through a vee belt at 375 r.p.m. Opposed connecting-rods coupled to a crankpin actuate reinforced moulded rubber diaphragms clamped to the pumping chambers. The two sorts of valves which can be fitted for high or for low-pressure applications are readily interchangeable without need for breaking any pipe connections. Truncated conical moulded rubber valves used for low-pressure applications have three cuts in the apex, and in operation, open and shut tulip fashion. Moulded rubber disc valves used in high-pressure applications are held in place by ebonite or stainless steel screws on perforated ebonite or metal seats. An air bottle is fitted on the delivery side of each pump chamber.

According to the duty for which they are intended, these pumps are fitted with either ¾ or 1¼ h.p. motors. With a ¾ h.p. motor drive and fitted with low-pressure valves, the makers state that one of the pumps can deliver from 570 gallons at 3 lb per square inch to 345 gallons at 40 lb per square inch. With high-pressure valves and using a 1¼ h.p. motor drive, a pump is designed to deliver from 600 gallons at 3 lb per square inch to 470 gallons at 70 lb per square inch. A suction lift up to 25ft can be obtained with reduced outputs of horsepower of motor, depending upon the specific gravity of the liquid pumped.

In addition to its diaphragm pumps, the firm will also exhibit a range of its centrifugal pumps from ¾in to 6in which incorporate a number of detail improvements.

Rockweld, Ltd.

Amongst the new electrodes to be shown on the stand of Rockweld, Ltd., Commerce Way, Croydon, Surrey, are six types for welding stainless and heat-resisting steels as well as two new types for mild steel. Two new lime ferritic hydrogen-controlled electrodes known as "Basac 35" and "45," are stated by the firm to be particularly suitable for welding 45 and 55-ton steels.

In connection with the "Oxyarc" cutting process an improved gun-holder, which is illustrated in Fig. 4, has been introduced by the firm. In this process, which is now fairly widely known, the metal is cut by the use of a fine point concentration of heat, generated by an electric arc and a stream of oxygen. The arc is established between a coated tubular electrode and the metal to be cut. Oxygen is fed through the hollow core of the electrode, which is consumed during cutting.

The high temperature of the arc allows cutting to start immediately without preheat; oxidation-resistant materials to be cut and pierced; the high-speed cutting and piercing of steel, and the piercing and cutting of composite parts, discontinuous superimposed plates, heavily rusted parts, &c.

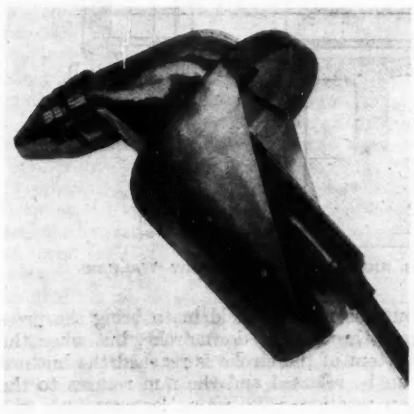

Fig. 4—"Oxyarc" Gun Holder—Rockweld

The improved gun, which is completely insulated and metal-clad, has an improved oxygen seal to give better sealing properties and longer life. It has a combined oxygen and electric cable of concentric construction so that a single lead only is required for the gun. The electrical conductivity and contact with the electrode have also been improved in the gun and a chuck-type electrode grip gives quick and positive engagement.

The range of arc welding transformers made by the firm has been increased by the introduction of two new oil-cooled welding transformers. One of these units is small, and provides a current range of 18A to 160A by fifty-six steps. It incorporates a tapping suitable for the use of a double-carbon torch, which can be used instead of the normal gas torch for brazing and welding operations. The other new transformer has a range of 35A to 400A by fifty steps.

Birlec, Ltd.

The furnace equipment which hitherto has been the predominant feature on exhibition stands of Birlec, Ltd., of Tyburn Road, Birmingham, 24, is this year being replaced by examples of the firm's "Lectrodryer" equipment for the controlled dehydration of gases and certain organic liquids. To fill the need for dry air or gas in many different industries the drying units are made in two general classes—for humidity control of large enclosed spaces, and for the drying of gases for processes such as furnace atmosphere control, instrument operation, &c.

The "Lectrodryer" units employ activated alumina as the drying agent. By using two beds of alumina in each unit, one adsorbing and the other being reactivated, continuous drying takes place. Whilst a unit is in operation the functions of the two beds are alternated either manually or automatically on a predetermined cycle.

One of the units to be exhibited is a model "BWC 1500" process gas dryer, with a capacity of 1200 cubic feet per hour, which is to be installed in an oil refinery for maintaining a supply of dry air to air-operated instruments. In it the alumina is reactivated by steam and the outlet gas can be dried to a very low moisture content. An air-conditioning plant to be shown on the stand is designed to supply continuously over 20,000 cubic feet of dehumidified air per hour.

J. H. Fenner and Co., Ltd.

Amongst the power transmission equipment to be exhibited by J. H. Fenner and Co., Ltd., Marfleet, Hull, is the "Taper Lock" bush, which is now being made under licence by the company. This bush provides a simple means of fastening pulleys to shafts and, as can be seen from Fig. 5, it consists of two main units—the bush and a housing—which incorporate the pulley and two or more socket head screws.

The bush is tapered on its outside diameter and is bored parallel and keywayed to British Standard sizes. It is split longitudinally through one wall. When the bush is inserted in the tapered bore of the pulley unit the tightening of the setscrews draws it into the bore and closes it in to grip the shaft. The angle of the taper in the pulley bore and on the outside of the bush is such that the use of a key between the two is unnecessary, as the friction caused by the wedging action will take the full weight of the shaft. It will be noticed that the holes for the screws are threaded on the pulley only.

In assembling a unit the bush, with its pulley fitted but not tightened, is simply slipped into position and by tightening the setscrews it is firmly fixed. When the pulley is to be removed from the shaft the screws are slackened and one is taken out and inserted in a jacking-off hole, after which, when it is given two or three turns, the wedging effect of the tapers is relieved.

The makers point out that the bush requires no space beyond the pulley, and it can be used with any size or design of pulley. Each stock pulley made will take the full range of taper bushings which are interchangeable to suit any shaft diameter.

One of the outstanding exhibits will be a 200 h.p. drive comprising pulleys 12⅞in and 96⅝in diameter, with sixteen vee belts, which is thought to be the largest drive ever shown at the B.I.F. Also to be shown for the first time is this firm's new "Fenaplast" non-inflammable solid woven belt for power transmission and for convey-

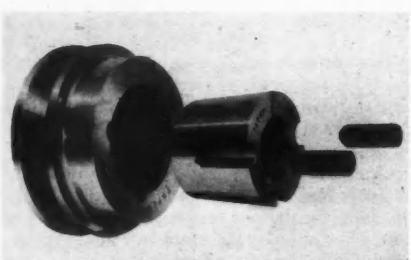

FIG. 5—TAPER LOCK BUSH—FENNER

ing, particularly in collieries. In these belts the load-bearing centre is made from low-stretch tough rayon, and the belt is impregnated and sealed with a hard plastic coating. It is pointed out by the makers that in these belts the rayon centre provides great strength equal to that of two normal plies compressed into one. The honeycomb outer weave forms pockets for holding or keying the plastic which has a very high coefficient of friction, and, on flexing, the belt surface makes a raised pattern which grips the pulleys exceptionally well. The plastic coating on the belts is flameproof, and resistant to most acids and solvents, and moisture.

Cowlishaw Walker and Co., Ltd.

From its range of power presses Cowlishaw Walker and Co., Ltd., of Biddulph, Stoke-on-Trent, has selected for exhibition at Birmingham its 75-ton "O.T.60" model. This machine was originally intended for auxiliary press operations in motor-car body shops, but is now being widely adopted for general-purpose work. It has an adjustable bed which can be swung clear for the attachment of special knee beds.

This firm will also show a working model of its air-operated clutch-brake unit which is fitted to all presses of 100 tons capacity and over. The construction and operation of the unit can be clearly followed by reference to the drawing reproduced in Fig. 6. When the press start button is depressed a solenoid is energised to open an air valve which admits air under pressure into a chamber *A* bored in the clutch shaft. The air passes through passages bored in the clutch centre member, which is keyed to the shaft, and enters the bore of an annular cylinder *B*. An annular piston *C* in the cylinder is forced outwards by the air pressure and clamps the clutch discs *D* against the clutch collar *E*. This collar is part of the clutch centre member, and, whilst air pressure is maintained on the piston, power is transmitted from the roller bearing mounted flywheel to the shaft and gearing of the press.

When the press start button is released, current is cut off from the solenoid and the air valve is closed, at the same time the air in the clutch cylinder is released to atmosphere. The heavy coil springs *F* force the piston in to its original position and through the rods *G* draw in the plate *H* to clamp the brake discs *J* against a brake collar *K*. The brake housing is secured to the press frame and application of the brake discs brings the shaft and gearing to a standstill.

The clutch control panel incorporates a rotary selector which can be set to a required sequence and locked. This selector switch has four setting positions—off, inch, momentary and long. In the inching position of the selector the circuit is completed to actuate the solenoid valve only as long as the inch button is kept depressed. With the selector in the momentary position the press completes one working cycle, and comes to rest automatically in the top stroke position, when the run button is depressed. When the selector is set in the long position the run buttons must be held in to bring the press ram through the downstroke, but when the bottom of the stroke is reached the buttons can be released and the ram returns to the top position. With this last sequence the press operator is protected, as to hold in the run buttons his hands must of necessity be clear of the moving ram.

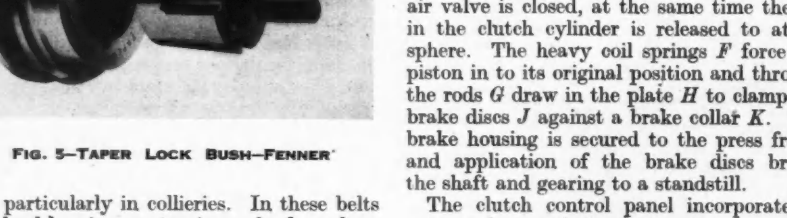

FIG. 6—ARRANGEMENT OF PRESS CLUTCH AND BRAKE—COWLISHAW WALKER

Barber-Greene Olding and Co., Ltd.

Prototype machines exhibited last year at Castle Bromwich included the new "Junior" model of the Barber-Greene Olding and Co., Ltd., bituminous road surface finisher. These machines are now in production at the firm's works at Hatfield, and incorporate a number of modifications on the prototype design.

The new range of small machines is similar in most respects to the makers' well-known standard crawler-mounted, self-propelled units developed to receive and lay all types of bituminous surfacing materials. The "Junior" finisher lays a normal width of carpet of 7ft and this may be increased in 3in increments to a maximum of 8ft 6in or reduced to 5ft 6in. Surface thicknesses can be varied between ½in and 6in, and the machine compacts and tamps the material as it is laid, filling in all irregularities and providing a surface of uniform density.

The machine is driven by a 33 h.p. petrol or a diesel engine through a gearbox which gives eight operating speeds from about 8ft to 44ft per minute. A flat fixed screed unit fitted to the prototype machine was mainly useful for flat surface work, but a split screed and crown control unit now fitted to the production model makes it adjustable to cambered surfaces.

E. Boydell and Co., Ltd.

Amongst the contractors' plant exhibited for the first time at the Fair is the new "L.H.1" hydraulic loader made by E. Boydell and Co., Ltd., Old Trafford, Manchester, 16. The compact design of this machine can be seen from the photograph reproduced in Fig. 7. It is 10ft 6in long overall, 4ft 3in wide, and 5ft high, with the bucket lowered. The 10½ cubic feet bucket has a maximum dump clearance of 5ft, the clearance under its hinge being 6ft 4in. The low height of the machine and its small turning circle of 15ft make it particularly suitable for working under confined conditions.

The loader is driven by a 35 h.p. petrol or a diesel engine and speeds up to 12 miles an hour are obtainable. The system of levers

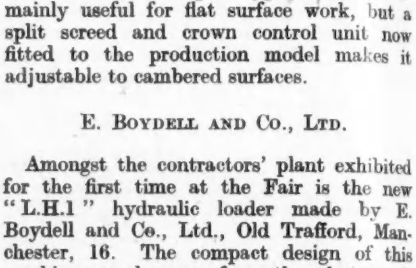

FIG. 7—SMALL HYDRAULIC LOADER—BOYDELL

on which the bucket is suspended, and through which its movements are controlled, is operated by hydraulic jacks. With the bucket control gear fitted, a straight or a measured tip can be obtained.

Engine power is transmitted through a two-speed gearbox, a fully flexible prop shaft, a worm reduction final drive and fully floating axles.

With this new machine the makers state that loading can be carried out at over 20 tons per hour and unloading at over 25 tons per hour.

(To be continued)

Historic Development of the Theory of the Flow of Water in Canals and Rivers*

By SERGE LELIAVSKY BEY, Ph.D., M.I.C.E., M.Am.Soc.C.E.

No. III—(*Continued from page 501, April 20th*)

The "Friction Fallacy" and the Hydraulic Effect of the Physical Characteristics of the Channel.

THE main point of Galileo's friction fallacy (namely, that given a certain difference of levels at the entrance to, and exit from, a canal, the velocity is independent of its length) has already been explained. This fallacy was shared by quite a number of Italian engineers of the seventeenth century, among whom was the well-known Guglielmini (1697). More maturity was displayed, during this early stage of the evolution of hydraulic principles, by the French physicists of the period. For instance, by the end of the seventeenth century Mariotte realised the retarding effect of "friction"; an effect that had been attributed by Guglielmini's school to cross currents alone, regardless of the resistance afforded by the solid trough.

It is somewhat surprising that whilst the fundamental equations of theoretical hydromechanics were already known in the middle of the eighteenth century, the errors of Galileo's school in regard to practical hydraulics were not fully realised (and corrected) until some thirty years later.

The credit for making the correction is differently attributed by various authors to either Dubuat or to Chézy. The truth appears to lie in the fact that the former was responsible for having stated the principle of the new concept, namely, that the frictional resistances in uniform flow were equal to the acceleration forces,[23] whilst Chézy devised the formulæ framing the idea.[24]

Consider a length L of a uniformly flowing canal or river in between the sections $A\ B$ and $C\ D$ (see Fig. 17). The sectional area being a, the volume of water coming into consideration is La and its weight γLa, where γ is the specific weight of the water. The component of this force parallel to the direction of the flow is $\gamma La \sin i$. As the angle $i = \sin^{-1} h/L$ is very small, we can substitute for sin i either of the two numerically equivalent values tan i or i, which are both usually referred to as the slope, or hydraulic gradient, of the water stream.

The force γaLi must now be equated to the frictional resistances. These are supposed to be proportional to the area of contact between the water and the solid trough pL (where p is the wetted perimeter of the section) and to some function of the velocity v. From the rather limited volume of field data, which Chézy had at hand, he nevertheless derived a reasonably correct conclusion, namely, that this function approximated to the square power of the velocity.

The equation, therefore, became

$$aLi = KpLv^2,$$

where K was a coefficient.

Re-arranging and adopting the letter m for representing the "hydraulic radius" or "hydraulic mean depth" a/p, we obtain the well-known equation

$$v = C\sqrt{im},$$

which bears the name of Chézy.

It may possibly seem surprising that the rather crude solution embodied in this formula became a universally-known principle of hydraulics, which sufficed to preserve the name of Chézy till our own days. But here, again, it is the historical hinterland which matters. In fact, Chézy's equation was a drastic negation of the principles of the earlier Italian school, which were still shared by many engineers of the eighteenth century. The fame, therefore, of the formula depended not only on its intrinsic value, but rather on the fact that it succeeded in setting aside an earlier tradition, which interfered with the normal development of practical hydraulics. This explains why, until now, we still refer to C as "Chézy's coefficient."

While Chézy's formula may be considered as having terminated the "friction" controversy, it was rather unfortunate that its

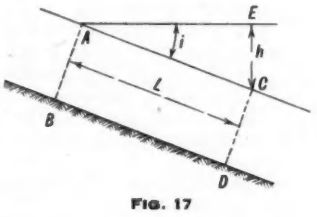

FIG. 17

interpretation led to another fallacy, concerning the hydraulic influence of the rugosity of the channel. Broadly speaking, there were two questions which attracted the attention of hydraulic engineers in the early post-Chézy period. These were:—

(*a*) Whether frictional resistances were indeed proportional to the square of the velocity (as assumed by Chézy) or to another function thereof;

(*b*) whether the coefficient C varied with the physical nature of the channel, or remained constant for all types of channels.

The combined result of the many attempts to solve these two problems was a large number of "discharge formulæ," intended to represent symbolically the interdependence between the velocity, the hydraulic gradient and the hydraulic radius. As in the majority of cases, the reply to question (*b*) was in the negative, these formulæ aimed at universal application, to all cases of canals and rivers met with in engineering practice.

The source of the heresy lay in the assumption that a thin film of water adhered to the surface of the solid trough, and that, therefore, the frictional resistances at the boundary did not develop between the water and the solid material of the channel, but between the moving water and the stationary film. Thus, it was alleged that the material of the channel did not come in direct contact with the flowing water and could have, consequently, no quantitative effect on the intensity of the flow.

It is rather curious to observe that the latest theories on the subject tend, again, to substantiate the existence of such a film; but only where a laminar boundary sub-layer is capable of developing. The conditions which qualify the scope of application of this new principle are, however, such as to confine it, chiefly, to laboratory practice. In historical perspective, the concept of the stationary film, injudiciously applied, as it was, in the first half of the nineteenth century, hindered, rather than stimulated, the further advance of hydraulic theory.

From among the various proposed solutions of this period, there can be quoted the equation of Prony, for it embodied a rather original idea; namely, it tended towards applying to the case of channel flow the empirical results arrived at by Coulomb with solid spheres moving in still water. That the analogy between these two phenomena must lead to numerically equivalent results, and be framed by similar formulæ, was an advanced idea worth recording at this early period.

Coulomb found that the force (drag) required to propel a solid body in a stationary liquid was equal to the sum of two terms, which were, respectively, proportional to the first and second powers of the velocity.[25] The original suggestion to use the same principle for the calculation of the discharge in open channels was made by Girard,[26] but in his equation (in feet) the same numerical coefficient appeared in both terms, whilst Prony's formula,[27] which was subsequently found capable of being used in practice, contained different coefficients, for the first and second powers respectively; namely:—

$$im = 0{\cdot}000{,}044v + 0{\cdot}000{,}309v^2.$$

Another set of coefficients was given by Eytelwein[28]; his formula was:—

$$im = 0{\cdot}000{,}024v + 0{\cdot}000{,}366v^2.$$

A more involved equation was suggested by Dubuat[29]

$$v = \frac{48{\cdot}85\sqrt{m} - 0{\cdot}80}{\sqrt{l/i} - \log_e\sqrt{(l/i)} + 1{\cdot}6} - 0{\cdot}05\sqrt{m},$$

whilst Courtois[30] came back to Chézy's original formula with

$$v = 50\sqrt{mi}.$$

This equation was, at a certain time, rather popular in Italy, where it was known as Tadini's formula.

On the other hand, Lahmeyer introduced[31] a new, rather ingenuous concept, i.e., he took into account the hydraulic effect of the curvature of the channel. For a radius r and width w, the equation was

$$\frac{mi}{v\sqrt{v}} = 0{\cdot}000{,}4021 + 0{\cdot}000{,}2881\sqrt{\frac{w}{r}}.$$

To apply this formula to a straight channel, make $r = \infty$, which, after transformation, gives

$$v = C\sqrt{mi} = 49{\cdot}87\sqrt[4]{v} \times \sqrt{mi}.$$

Still another type of empirical equation was proposed by Saint-Venant[32]; he used the exponential form,

$$v = 60(mi)^{11/21}.$$

To facilitate the application of this equation he published ready-made tables, in spite of which the formula does not seem to have ever been used in practice.

The variety of the equations quoted is characteristic of the period under review.

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* The opinions expressed in this article are those of the author and do not necessarily represent those of the Egyptian Ministry of Public Works.

[23] "... quand l'eau se meut uniformement, la resistance qu'elle éprouve est égale à sa force accélératrice," "Principes d'Hydraulique," paragraph 20.

[24] Handwritten text of lectures delivered by Monsieur de Chézy at the Ecole Royale des Ponts et Chaussées. Monsieur de Chézy was then (1775–1789) Chief of the Pavings of Paris, a high engineering dignity in pre-revolutionary France.

[25] "Memoires de l'Institut National," An IX, page 246.

[26] "Rapport sul le Canal de l'Ourg," An XII, page 36.

[27] "Recherches physico-mathematiques ..." 1804.

[28] "Proceedings" of Berlin's Academy, 1814–15.

[29] "Principes d'Hydraulique," 1816.

[30] "Traité de moteurs inanimés," 1850.

[31] "Erfahrungs-Resultate uber Gleichformige Bewegung," 1845.

[32] "Annales des mines," 1851.

That there were so many of them and that none was generally accepted or recognised was due to their common defect, viz., that they did not take into account the physical character of the channel. Since each formula was derived from a limited (though possibly quite substantial) number of observations, but aimed at being applied to all types of rugosities, it was only natural that, in spite of the mathematical ingenuity displayed in developing the equation, its result led always into a cul-de-sac.

So long, however, as all the factors coming into consideration, viz., the section of the channel, its slope and its physical nature, were independent variables, the individual parts played by each one of them were difficult to assess, and there was therefore not enough material to fight the routine of the "stationary film" as it was then applied. In order to prove that the physical nature of the channel had indeed a measurable influence on the discharge it was necessary to produce results obtained on channels which, while geometrically identical, were nevertheless made of different materials—a rather "tall order."

In spite of the inherent difficulties of this problem, it was solved in 1856 by d'Arcy and Bazin (with the help of the French Second Empire Government, which was ever anxious to display its liberal tendencies, and sponsored, therefore, the experiments, providing the funds required to organise and carry out an extensive programme of investigations).

A 596·5m long channel, drawing its supply from the Burgundian Canal, near Dijon, and escaping into the River Ouche, was used for carrying out the experiments. It was provided, *seriatim*, with various classes of linings, for rectangular, trapezoidal, triangular and semi-circular sections. In this manner incontrovertible proof was supplied of a significant correlation between the material of the lining and the discharge.

From these results d'Arcy and Bazin derived the formula

$$C=\sqrt{\frac{1}{a\left(1+\frac{b}{m}\right)}}$$

in which both a and b were numerical coefficients.

As a declaration of faith this formula attracted considerable attention and was translated into almost every European language, but the fact that it contained two variable coefficients stood in the way of its easy practical application, which explains why another formula, embodying the observational material of d'Arcy and Bazin, as well as that of Humphrey and Abbot and many others, became rather popular in the second half of the last century. According to this new formula, which was due to two Swiss, Ganguillet and Kutter,[33] the coefficient of Chézy was dependent on both the hydraulic radius and the hydraulic slope, but included only one constant representing the rugosity, as follows, in English units :—

$$C=\frac{41\cdot6+\frac{1\cdot8112}{n}+\frac{0\cdot00281}{i}}{1+\left(41\cdot6+\frac{0\cdot00281}{i}\right)\frac{n}{\sqrt{m}}}$$

in which n is a rugosity factor.

An elaborate set of coefficients was subsequently produced by American engineers, who seem to be very fond of this formula,[34] The following is an abstract of a list published in 1916 by Mr. Horton (*Engineering News*, February 24, 1916) :—

Pipes and Conduits	Kutter's n
Coated cast iron pipe	0·013
Commercial wrought iron pipe, galvanised	0·015
Smooth brass and glass	0·011
Riveted steel	0·017
Vitrified sewer	0·015
Wood-stave pipe	0·012
Plank flumes, unplaned	0·014
Semicircular metal flumes, corrugated	0·0275
Canals and Drains	
Earth, straight and uniform	0·0225
Rock cuts, smooth and uniform	0·033
Rock cuts, jagged	0·045
Canals with rough, strong beds, weeds on earth banks, &c.	0·035
Natural Streams	**Kutter's n**
Clear, straight, no rifts or pools	0·030
Winding but clean	0·045
Sluggish, rather weedy, or deep pools	0·070
Very weedy reaches	0·125

Though the formula is very popular, there is much to be said against it, particularly in regard to the manner in which it was developed. In the first instance one cannot combine in one and the same empirical equation the experiments of d'Arcy and Bazin, on the one hand, and those of Humphrey and Abbot, on the other; for the simple reason that the order of procedure adopted in these two sets of observations was essentially different. In fact, whilst in the first case the discharge records were taken on an artificial channel in which the bed slope was made to vary at the same time as the surface slope, the second set of observations was collected on a natural river, with constant bed slope. Thus the specific conditions of uniform flow were fully realised in one case but were not in the other.

In fact, as will be seen from the following table, the coefficient C increases with i for values of m less than 1m (such as in the d'Arcy-Bazin experiments), but drops when i rises for m greater than 1m (which is characteristic of the scope of observations of Humphrey and Abbot).

m, in feet	C, according to the formula of Ganguillet and Kutter, in foot units			
	$n=0·010$		$n=0·030$	
	$i=0·0001$	$i=0·001$	$i=0·0001$	$i=0·001$
0·5	126	138	33	36
1·0	148	156	42	45
2·0	168	172	52	54
4·0	186	185	64	63
6·0	195	191	70	68
10·0	200	197	78	74

The second objection is that the formula is unnecessarily complicated. It was therefore natural that various simplifications were suggested which were claimed to lead to practically the same quantitative result, with much less arithmetics.

These are: the so-called "reduced" formula of Kutter, the Gibson's formula, and the formula of Manning. It will be observed that in all three cases the effect of i on C is altogether disregarded.

The first formula reads, in English units :

$$C=\frac{181\cdot12\sqrt{m}}{1\cdot81n+\sqrt{m}}.$$

The values of the rugosity factor n are :

	n
Very smooth boundary	0·10
Neat cement plaster and very carefully planed timber	0·15
Well-jointed timber	0·20
Usual finish; timber, ashlar	0·25
First-class rubble masonry; good brickwork	0·35
Ordinary rubble masonry and brickwork	0·50
Old masonry and unplastered concrete	1·00
Earthen channels in excellent condition	1·50

According to Lueger this simplified formula yields satisfactory results for $i>0·0005$. On the other hand, Rennelin finds that it is as good as the more complicated equation for all slopes met with in practice.[35]

Gibson[36] observes that by altering the value of i in Ganguillet-Kutter formula from 0·001 to 0·01, the value of C is altered less than 1 per cent. For streams with rather rapid slope, he therefore suggests the formula, in English units :

$$C=\frac{44\cdot4+\frac{1\cdot811}{n}}{1+44\cdot4\frac{n}{\sqrt{m}}}$$

which is the precise value of the coefficient for C for $i=0·001$.

The values of n to be introduced in this formula are the same as for the original equation. Manning proposes the formula, in English units :

$$C=\frac{1\cdot486}{n}R^{1/6}.$$

According to Manning, this equation is numerically equivalent to that of Ganguillet and Kutter, if we include in it the same values of the rugosity factor n. Strictly speaking, this is not entirely correct, for the respective expressions do not lead to the same numerical result, but practice shows that with a slight alteration of the corresponding rugosity coefficients, Manning's formula is as good as that of Ganguillet and Kutter. Being much simpler, it lends itself splendidly to practical use, and is therefore very popular, at present.[37] In the Egyptian irrigation system, the formula is commonly applied to canals in normal condition with $n=1/40$.

To avoid confusion, it is advisable to mention that Manning has also produced another coefficient, applicable to natural large rivers only, the idea being that the section of an alluvial channel, created by the scouring action of the flowing water, must of necessity depend on the velocity, and is, therefore, in itself a function of the rugosity coefficient. Which means that this coefficient is naturally interrelated with the width and depth of such a stream, and need not, therefore, appear as an independent numerical constant in the relevant formulæ.

This, indeed, is the basic principle of the new ideas of the Austrian school on the subject. It led Manning to propose the following equation, in English units :—

$$C=62\left(1+\frac{\sqrt{m}}{7}+\frac{0\cdot05}{\sqrt{m}}\right).$$

Further, developed equations belonging to the same group will be given later.

At the present juncture attention is called to another discharge formula, which is comparable in value and popularity to those of Ganguillet and Kutter, and Manning, viz., the "new" formula of Bazin, or, briefly, "the Bazin formula" (in contradistinction to "the d'Arcy and Bazin formula," which title is supposed to refer to the earlier equation). Realising the objections against two mutually interfering rugosity factors appearing in the same formula, Bazin published, in 1897,[38] a new equation, with one variable coefficient only, as follows, in English units :—

$$C=\frac{157\cdot6}{1+\frac{1\cdot81\gamma}{\sqrt{m}}}.$$

[33] "Versuch zur Aufstellung einer . . . Formel . . .," Bern, 1877.

[34] Cf., "Calculation of Flow in Open Channels," by I. E. Houk (Miami Conservancy Report, 1919) and many other American publications on the subject.

[35] "Wie bewegt sich fliessendes Wasser?" 1913.

[36] "Hydraulics and Its Applications," page 292.

[37] The same formula was suggested earlier by Ph. Gauckler, "Annales des Ponts et Chaussées," 1869.

[38] "Annales des Ponts et Chaussées," 1897.

The **rugosity factor** γ **is as follows :—**

Type of Channel	Bazin's γ
Smooth plaster, planed timber	0·06
Timber, ashlar, neat brickwork	0·16
Rubble masonry	0·46
Plaster, very smooth earth	0·85
Earth channels in usual condition	1·30
Earth channels, bed condition	1·75

All the three formulæ cited (i.e., the formulæ of Ganguillet and Kutter, Manning and Bazin) are still widely used at present.

To facilitate their application, various tables and diagrams have from time to time been produced. It will be observed, however, that since the formula of Ganguillet and Kutter depends on three variables, the relevant tables are rather voluminous.

On the other hand, Manning's and Bazin's coefficients can easily be tabulated, with enough precision for practical use.

Following the publication of d'Arcy-Bazin experiments and the final abandonment of the ancient tradition, a wide field was opened for individual hydraulic investigators whose engineering activities concerned open-channel flow. Little wonder, therefore, that an almost infinite number of discharge formulæ were developed and published in the second half of the last century and in the beginning of the present. It is out of the question to quote all these equations. The main "ideological" tendencies only will therefore be referred to, which represent, in a sense, the characteristic trends of modern ideas on the subject.

For instance, the wide popularity of computation methods based on logarithmic squared paper in English-speaking countries has stimulated the production of several "exponential" formulæ similar in principle to that of Saint Venant but containing a variable term representing the rugosity of the channel. The only difference between such equations—which are advocated, for instance, by Professor Lea[39] and Mr. Barnes[40]—and Bazin's formula, is that, instead of the hyperbolic anagram used by the latter (in which $\frac{a}{b+f(y)}$ is plotted against x, leading thus to a straight line), they are based upon the logarithmic anagram (in this case log $(a+x)$ is plotted against log $(b+y)$, in order to obtain the same result). Which of the two methods is preferable, is a purely formal question.

Another group of investigators made the discharge coefficient a function of the acceleration of the force of gravity g. This again is a formal alteration only, for any one of the quoted equations for the coefficient C can be rewritten in such a manner as to include the practically constant value of g; but this method of transcription has the academical advantage of making the discharge formula homogeneous and therefore independent of the system of units used. In practice, formulæ belonging to this group found their application chiefly in the design of pipes rather than open channels.

The transformation is performed as follows :—

$$\text{Writing } C=\sqrt{\frac{8g}{f}}$$

and substituting this into Chézy's equation,

$$v=\sqrt{\frac{8gmi}{f}}.$$

For circular pipes $m=D/4$; if y represents the loss of head over a certain length L, so that $i=y/L$, we then obtain

$$y=f\frac{L}{D}\frac{v^2}{2g}.$$

With this notation d'Arcy-Bazin formula changes into

$$f=0\cdot01989+\frac{0\cdot0005078}{D}\quad(\text{for } D<0\cdot5mi).$$

For the same coefficient Weisbach gives

$$f=0\cdot01439+\frac{0\cdot0094711}{\sqrt{v}}.$$

A still more involved equation was devised by Biel,[41] in which apart from the rugosity factor, he also included the coefficient of dynamic viscosity $\frac{\mu}{\gamma}$, as follows :—

$$f=0\cdot0785\left(0\cdot12+\frac{2a}{\sqrt{D}}+\frac{2b}{v\sqrt{D}}\frac{\mu}{\gamma}\right).$$

The coefficients a and b appearing in this equation were dependent on the material of the channel. The practical advantage of such involved equations appears to be doubtful.

(To be continued)

[39] "Hydraulics," London, 1921.

[40] "Hydraulic Flow Reviewed," London, 1916.

[41] "Forschungsarbeiten des Ver. deutscher Ingenieure," Heft 44, 1907.

Present-Day Locomotive Working in Great Britain

Part II—The Western Region "Castle" Class

By O. S. Nock, B.Sc., A.M.I.C.E., M.I.Mech.E.

(Continued from page 503, April 20th)

To indicate the standard of individual performance put up during the year 1950, details are next given of three footplate journeys, covering the three varieties of boiler :

(1) Low superheat example, engine 4000, "North Star."

(2) Medium superheat example, engine 7036, "Taunton Castle."

(3) High superheat example, engine 5049, "Earl of Plymouth."

Further, to indicate the soundness of the base upon which the "Castle" design was prepared in 1923, and as one more tribute to the memory of Churchward, details are included of a remarkable trip on the footplate of a "Star" class engine, of the series named after "Princesses," built in 1914, and working the 7.15 a.m. express from Plymouth to Paddington in August, 1950. With some of these journeys noted from the footplate during the past year it should be emphasised that the overall speeds were not as high as those of the corresponding trains prior to 1939; but the details of engine performance speak for themselves.

Plymouth to Paddington with a "Star"

The 7.15 a.m. express normally takes only a modest load by the standard of the Western Region West of England services; six coaches from Plymouth and four from the Torquay line attached at Newton Abbot. Over the gradients of the South Devon line the load limits are 288 tons for a "Star" and 315 for a "Castle," so that our 200 tons tare from the start was comfortably within the maximum. Although heavy rain at times made things somewhat unpleasant in the attenuated Churchward cab, the rain was so heavy as to remove any greasiness from the rails, and we had no anxieties from slipping on the ascents to Hemerdon and to Dainton tunnel. The engine was one of the last batch constructed, No. 4054, "Princess Charlotte," built in 1914, and apart from her being in first-class condition, the 4051–4060 series are liked by the enginemen as the reversing screw is placed well forward into the cab and allows of a comfortable stance, instead of the awkward position necessary with all other Churchward express 4–6–0s, due to the projection of the reverser almost to the extreme rear end of the locomotive footplate. With the light load of 200 tons tare, interest in the Plymouth–Newton Abbot run was confined to the ascents of Hemerdon and Dainton inclines. They are shown diagrammatically in Fig. 4. The attack upon the 1 in 41 gradient of Hemerdon is nowadays made in more difficult conditions than previously, due to the permanent speed restriction of 35 m.p.h. at Tavistock Junction, only a mile from the foot of the 1 in 41; whereas in former days eastbound trains used often to pass through Plympton station at 55, or, as I once noted on the Cornish Riviera Express in 1924, a full 60 m.p.h., the initial speed nowadays is rarely more than 45 m.p.h. On this run with No. 4054, the sustained minimum speed of 17¾ m.p.h. from 44 m.p.h. through Plympton was good. This, working in 45 per cent cut-off, was equal to a drawbar pull (corrected for gradient) of 8·4 tons, 68 per cent of the nominal tractive effort of the locomotive.

The faster stretches from Hemerdon box gave ample opportunities for observing the excellent riding qualities of the engine, on a winding difficult road, while, in climbing to Dainton tunnel, the restriction of speed to 40 m.p.h. throughout from Totnes gave no chance of the final gradients being charged, as in former days. For the last ¼ mile here cut-off was advanced to 50 per cent. This stretch is not, even at the best of times, an economical one from the locomotive point of view; although heavy steaming is confined to the two short spells on Hemerdon and Dainton inclines, coal and water are being used during the periods of light steaming, and on this occasion the tender gauge showed a consumption of 1000 gallons of water between Plymouth and Newton Abbot, 31·8 miles, covered in 55½ min inclusive of an intermediate stop of 57 sec duration at Totnes and a signal check from 45 to 20 m.p.h. at Ivybridge.

At Newton Abbot the load was made up to ten coaches, 324 tons tare, 345 tons full, with passengers and luggage. Stops are made at Teignmouth and Dawlish, and with a long permanent way slack to 40 m.p.h. past Exminster, the initial 20·2 miles to Exeter took 36 min. Real express running began at Exeter. The allowance of 38 min, start to stop, for the 30·8 miles from Exeter to Taunton is not quite equal to the fastest booking of pre-war days in this direction, when certain trains were booked in 35 min, start to stop. The succeeding allowance of 160 min non-stop for the 142·7 miles to Paddington is considerably slower than the 142 min allowance of 1938–9, which, moreover, then included a 2 min stop intermediately at Westbury. The load in those pre-war years was, however, one of only eight coaches, approximately 250 tons. It was clear, however, from the running of engine No. 4054 that times approaching pre-war figures could easily have been achieved, if

necessary, despite the heavier load. In making up time after a late start from Taunton, the 142·7 miles were covered in 153¼ min, and this included what would, in pre-war years, have been thought a very slow finish over the favourable 70 miles from Savernake into Paddington—a time of 73 min.

Details of the performance from Taunton to Paddington are given below :

Length of trip, miles	142·7
Actual time, minutes	153¼
Net time, allowing for two signal checks, minutes	151
Net average speed, m.p.h.	56·7
Steaming of engine :	
Main regulator valve used, miles	52
First regulator valve used, miles	83
Cut-off 15 per cent, miles	129
Cut-off 25 per cent, miles	4½
Cut-off more than 25 per cent, miles	1½
Water consumption from tender, gallons	3500
Total estimated evaporation (allowing 10 per cent for exhaust steam injector), gallons	3850
Water consumption per train-mile, gallons	25
Estimated coal consumption per train-mile, pounds	27

A summarised log of the journey is as follows :—

Distance	Stations	Time	Average speed	Nature of road
Miles		Min sec		
0·0	Taunton	0 00		
			48·1	Level
11·9	Curry Rivel Junction	14 50		
			59·3	Slightly adverse
27·6	Castle Cary	30 44		
			47·3	Heavily adverse
34·3	Strap Lane Halt	39 14		
			59·1	Favourable
48·1	Heywood Road Junction	53 14		
			54·8	Adverse
72·6	Savernake	80 05		
			58·8*	Favourable
106·7	Reading	141 51		
			59·1	Level
139·4	Old Oak Common West Junction	148 02		
142·7	Paddington	153 12		

* Includes 2¼ min lost by signal checks.

In quoting cut-offs the percentages given are in all cases those read from the scale of the reverser. I am aware that there are many engines running in this country on which the calibration is not entirely correct and may give a misleading impression of engine performance. But with Great Western four-cylinder 4–6–0s of all varieties I have found there is such consistency in the methods of driving, and in the cut-offs shown on the scale, that I feel general reliance can be placed upon the figures shown—at any rate, to within plus or minus 2 per cent of cut-off.

It is immediately noticeable from the timings how the engine was restrained on the favourable stretches. By way of contrast one pre-war occasion may be mentioned when a "Star" class engine hauling 315 tons ran from Savernake to Reading in 29¾ min (68·8 m.p.h.), and from Reading to Old Oak Common West Junction in 28½ min (68·7 m.p.h.). This performance of No. 4054 in August, 1950, with its very low coal and water consumption, consistently free steaming, and high power output on early cut-off, shows a Churchward four-cylinder, 4–6–0 at its best—thirty-six years after the construction of the engine. It was on the strength of such performance that the enlarged version of 1923, the "Castle" class, was prepared.

"North Star"

In 1950, among the footplate journeys made on Western Region engines, only one, and a short trip at that, was made on a "Castle," with the original low-superheat boiler. That was, however, because I deliberately sought out the newer varieties. The older engines, well maintained, are still capable of repeating their optimum performance of twenty years ago, as an example of which may be mentioned a recent run of No. 5023, "Brecon Castle," on the 6.30 p.m. out of Paddington to Chippenham—one of those included in the summary table in Part I of this article—namely :

Length of trip	94 miles
Booked time	99 min
Load : 447 tons tare, 485 tons gross behind the tender	
Actual time	104 min 51 sec
Net time (allowing for three signal checks)	95¼ min
Net average speed	59·2 m.p.h.
Sustained speed on 1 in 754 gradient	62 m.p.h.
Estimated D.B. horsepower (corrected)	1258

Readers of The Engineer may remember that in the series of articles dealing with mixed traffic 4–6–0s I described in the issue for November 25, 1949, a run on the 2.9 p.m. express from Wolverhampton to Shrewsbury in which a high transitory horsepower was developed by a two-cylinder "County" class engine. This year I was able to observe the working of a "Castle" class engine on the same train, with the results shown diagrammatically in Fig. 6. The particular locomotive was no ordinary "Castle," but the pioneer Churchward four-cylinder engine "North Star," originally built as an "Atlantic" for comparison with the French compounds, later converted to a 4–6–0, and still later rebuilt with a "Castle" boiler. Although new cylinders and motion were fitted at the time of the second rebuilding—in 1929—the original frame remains. This celebrated engine was in great form, and handled a heavy train of 480 tons with ease. As will be seen from Fig. 6 no cut-off longer than 20 per cent was needed to climb the heavy gradient to Hollinswood, though a signal check outside Wellington caused the start-to-stop time from Wolverhampton to be nearly a minute over schedule, 23 min 54 sec to be exact. Down the falling gradients from the Wellington start the engine was worked very swiftly into speed, Walcot Station, 3·9 miles out, being passed in 5½ min at 67 m.p.h. Fast running continued to the outskirts of Shrewsbury, and although the finish here again was checked by adverse signals, the 10·2 mile run from Wellington was completed in 13½ min—smart work with a 480-ton train.

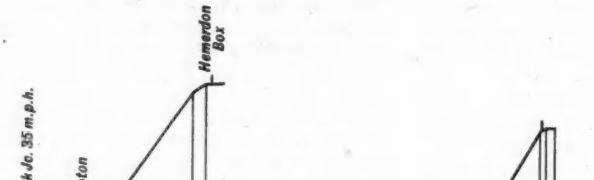


Fig. 4—Eastbound Inclines—South Devon Line

High Superheat

The use of modified superheaters on the "Castle" class engines was initiated by Mr. Hawksworth in 1946 ; but, in addition to putting a changed design of superheater on the new engines of the "5098" class, one of the standard engines was fitted, in 1947, with a four-row apparatus giving a high degree of superheat. Comparative details of the three varieties of boiler are shown in the accompanying table :

	Original "Castles"	"5098" series	Engine 5049
Heating surface in square feet :			
Tubes	1885·62	1799·5	1669·9
Superheater	262·62	295	393·2
Ratio of heating surface :			
Tubes/Superheater	7·18	6·1	4·25

Fig. 5—"Princess Charlotte" No. 4054 Running the 7.15 Plymouth to Paddington

The high superheat engine, No. 5049, "Earl of Plymouth," is stationed at Cardiff, and I was enabled to make a footplate journey on her on one of the regular London workings operated from that shed: 12.20 p.m from Cardiff, and the 5.55 p.m. down from Paddington, a round trip of 290·2 miles, with a turn-round time of 2 h 15 min in London. The engine was worked throughout by Driver Jones and Fireman Ivor Lewis, of Cardiff, with Inspector Tucker, also of Cardiff, on the footplate. The up train is allowed 106 min to cover the 67·8 miles from Cardiff to Swindon. This includes a station stop of 4 min at Newport, and provision for an assistant engine when the loading requires it, through the Severn Tunnel. The maximum load allowed unassisted to a "Castle" class engine up the heavy gradient, 1 in 100 for nearly 7 miles, is 455 tons, and when this is exceeded a stop is made at Severn Tunnel Junction to attach the bank engine, and a further stop is needed at Badminton to detach. The booked running time is only 95 min. On my trip, however, the load was no more than 400 tons tare, 430 tons gross behind the tender, but this restricted stage of the journey, appeared to be exceptionally economical on water; this was to be amply confirmed by the working between Swindon and Paddington. The running here is summarised, for both eastbound and westbound journeys herewith:—

Engine 5049: Swindon–Paddington

	Up	Down
Train	2.11 p.m. ...	5.55 p.m.
Distance...	77·3 miles ...	77·3 miles
Gradient (average)	1 in 1510 falling ...	1 in 1510 rising
Booked time	89 min ...	87 min
Load, tons tare ...	400 ...	439
Load, tons gross ...	430 ...	470
Actual time	86 min 42 sec ...	88 min 50 sec
Checks (number) ...	One ...	One
Net time	83½ min ...	86½ min
Net average speed	55·7 m.p.h. ...	53·5 m.p.h.
Maximum speed ...	65 m.p.h. ...	62 m.p.h.
Water consumed (tender gauge) ...	1650 gallons ...	2300 gallons
Water per train mile	21·3 gallons ...	29·7 gallons

From this table it will be seen that the loadings and booked speeds of these two trains happened, on this particular day, to be in inverse ratio to the haulage effort required. The 2.11 p.m. up was an easy train to work, and it was managed most economically. The 5.55 p.m. down is a hard turn, though although we had the advantage of running through Severn Tunnel Junction and Badminton without stopping harder work was entailed for the unassisted train engine on the bank, and we suffered, in addition, two severe signal checks—one right on the grade climbing from the tunnel, and a second, to walking pace, at Westerleigh Junction, in the middle of the 11-mile rise at 1 in 300 leading to Badminton. In spite of this our total time from Cardiff to Swindon was 102 min, 4 min less than booked, and our net time for the non-stop run of 56·1 miles from Newport was 74 min.

It is a very awkward section of line, and the small chances of settling down into that steady stride in which the "Castle" engines so excel, were made smaller still by the signal checks. The engine was, however, completely master of its load at all points, so much so, indeed, that Wootton Bassett, 50·5 miles from Newport, was passed 6 min early, and we had to ease down to avoid too early an arrival in Swindon. The general working position was 17 per cent cut-off, with the regulator about three-quarters full for the 1 in 300 bank, and first port only open on the level and downhill. The engine, even on in making a running average of 58 m.p.h. over the 55·7 miles from Slough to Marston East Signal Box, against the gradient, the cut-off was never advanced beyond 17 per cent, the regulator being about three-fifths open on the main valve. This working gave a continuous output of about 950 drawbar horsepower. It will be noticed how closely the speed over this stretch corresponded with the most economical working rate for this weight of train, as given in Table II of Part I.

On this particular evening a locomotive was required for an up fast freight train from Rogerstone yard, Newport, for which there was no balanced down working; so, to save light running, it was coupled on in front of No. 5049 at Swindon, and from the viewpoint of engine performance the run had no further value. But I had seen enough of No. 5049 to appreciate her economical working. How far this could be attributed solely to high superheat one would hesitate to say. The engine has been tested on the stationary plant at Swindon against standard and medium-superheat "Castles," and during last autumn she was put through a series of road trials with the dynamometer car for comparative purposes.

The "5098" Series

Of the Hawksworth variety of the "Castles," the "5098" series, forty have been built since 1946, and with several of these engines I have enjoyed excellent runs on the footplate. I have chosen for detailed reference one made in the autumn of 1950 on the harder of the two fastest trains on the West of England service. These include a flying average, over the 131·2 miles from Southall to Creech Junction, of exactly 60 m.p.h.—precisely equal to the most economical rate for a train load of 400 tons. Both the 3.30 p.m. and 5.30 p.m. expresses from Paddington are allowed only 148 min to cover the 142·7 miles to Taunton—58 m.p.h. average—but the 3.30 p.m. carries the heavier load during the period of the summer service. On the latter train we had one of the very recent engines of the class No. 7036, "Taunton Castle," completed at Swindon in August, 1950. The present 3.30 p.m. is in some ways reminiscent in its loading of the Cornish Riviera Express between the

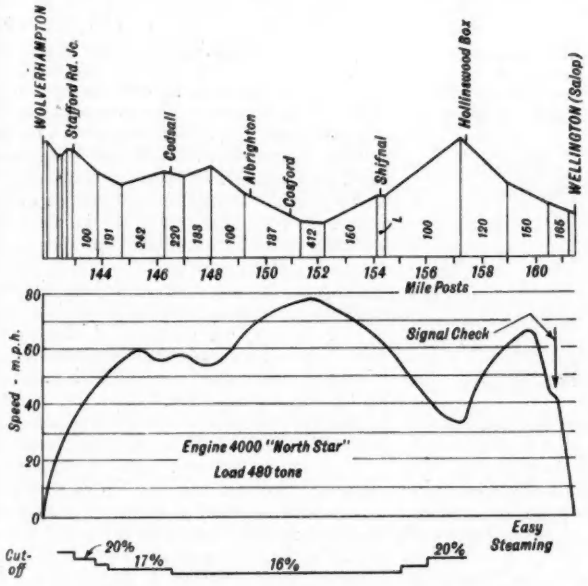


FIG. 6—ENGINE NO. 4000—WOLVERHAMPTON TO WELLINGTON

FIG. 7—"NORTH STAR" TO-DAY

"*Taunton Castle*" *No. 7036—Paddington to Plymouth*

Miles	Timing point	Load, tons gross	Schedule time (min)	Average speed	Nature of road
0·0	Paddington	430	0	—	—
36·0	Reading	430	39	55·5	Level
70·1	Savernake	430	77	53·9	Gradual rise
94·6	Heywood Road Junction	430*	99½	65·2	Favourable
142·7	Taunton STOP	390	148	59·5	Mostly favourable
10·9	Whiteball Box	390	16	40·9	Stiff rise
30·8	Exeter STOP	390	36	59·7	Favourable
20·1	Newton Abbot	260	25	48·3	Level
35·7	Brent	260	52	34·7	Very severe
52·0	Plymouth	260	75	42·5	Falling gradient

* Coach slipped at Heywood Road Junction (Westbury)

wars, in that its tonnage is reduced successively as the westward journey proceeds and the adverse gradients become increasingly severe. The loads and booked speeds may be summarised as tabulated on page 537.

To Exeter, although it is only on certain stretches that the general speed limit of 75 m.p.h. is relaxed to permit of running up to 85 m.p.h., there are but few restrictions. Beyond Exeter, however, the level stretch to Newton Abbot cannot, on account of curves, be utilised for fast running, and on the South Devon line the restrictions are so numerous that many of the downhill stretches might well be adverse for all their value for speed making. All in all, this is a hard train to work, and the booked overall running time of 259 min for 225·5 miles, 52·5 m.p.h., is a most creditable one; yet on this recent trip with No. 7036, mainly through the recovery from an exceptional delay, I was to see it out to a net time of 241 min, 56·2 m.p.h. average. But in view of such highly successful running it should be added that the conditions were not wholly favourable. Although the weather was mostly fine we were bucking into a strong head wind which did not die down until most of the faster running was over. On the other hand, the engine was fired with characteristic Great Western care and skill so that I saw that wonderful consistency of steaming that is traditional of Swindon boilers, and sometimes gives rise to humorous remarks about concealed weights hung on the gauge needle. On this trip, for 130 miles westward from Southall, the only occasions on which pressure fell below 220 lb per square inch were when the firing was deliberately eased, in anticipation of an easing of the engine itself to avoid blowing off. This occurred approaching Reading, with its 40 m.p.h. service slack over the west junction, and as Savernake summit was neared.

The engine was manned by Driver A. Cook and Fireman L. Hughes, of Old Oak Common shed, with Inspector G. Price, also of Old

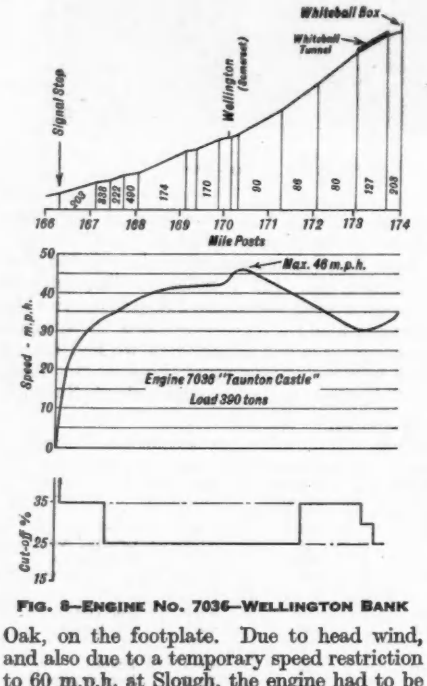


FIG. 8—ENGINE No. 7036—WELLINGTON BANK

Oak, on the footplate. Due to head wind, and also due to a temporary speed restriction to 60 m.p.h. at Slough, the engine had to be steamed a little harder than might otherwise have been necessary out to Savernake and, except for about 6 miles on 20 per cent after Reading, the cut-off was 22 per cent throughout from Southall to a point about 68 miles from Paddington; 25 per cent was used for the last 2 miles up to Savernake, where the gradient stiffens to 1 in 183, 1 in 145, 1 in 106. The summit was passed almost exactly on time, 70·1 miles in 76 min 42 sec., at 45 m.p.h. To this point water consumption was 2700 gallons, or 38½ to the mile.

Onwards to Taunton evidence that the engine was steamed much more easily is provided by the water consumption of no more than 2300 gallons in 73 miles, only 31½ to the mile; but that same stretch, 72·6 miles to be exact, was covered in 66 min 3 sec pass to stop. The fastest running was contained in two stages, over the 24·5 miles from Wootton Rivers to Fairwood Junction, and over the 28·6 miles from Bruton to Creech Junction; here the average speeds were 71·9 and 70·2 m.p.h. respectively, with peak rates of over 80 m.p.h. in each case. The intervening stretch of 14·7 miles, from Fairwood Junction, over broken rising gradients to the crest of the hills near Strap Lane Halt, was taken at an average of 59·6 m.p.h. with a minimum of 50½ m.p.h. Except on the 4 miles leading to Strap Lane, the cut-off lay between 18 and 20 per cent with no more than the first valve of the regulator, and speed limits were all carefully observed. Yet despite this relatively easy running, and the constant hindrance of the

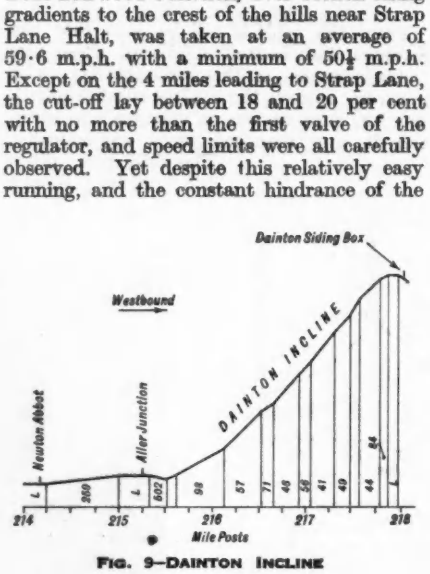


FIG. 9—DAINTON INCLINE

wind—very boisterous when we came down into Somersetshire—we passed Creech Junction, 140·3 miles from Paddington, in 139 min 9 sec. Although slightly checked by signal afterwards we stopped at Taunton in 142 min 45 sec, a start-to-stop average of 60 m.p.h.

The additional station time available through this early arrival gave ample opportunity to get coal forward for the next stages, and to go round the engine, then relatively new from the shops. But a point noticed at once as we drew into Taunton Station was that "The Devonian"—through express from Bradford to Kingswear—was only just preparing to leave, and was thus running some 30 min late. While there appeared ample margin as far as Exeter, since she would be preceding us by 8 min or 9 min, there was a prospect of delays farther west, as she had station stops to make at Dawlish, Teignmouth and Newton Abbot. As it happened we were in trouble much earlier than that, but not only from "The Devonian." A freight train was apparently taking an unconscionably long time to get over Whiteball summit, and while she did so "The Devonian" was stopped at Wellington, while we were checked through Norton Fitzwarren and stopped at Victory Siding Box. When finally we left the advanced starting signal, only 3¼ miles from Taunton, it was 11¾ min after we had left the station and all chances of taking a "run" at Wellington bank had been lost. The actual ascent, from a start on the approach gradients, was very fine, and it is shown, together with engine working details, in Fig. 8; but we had lost 9 min on schedule, and arrived in Exeter to find we were right on the tail of "The Devonian." We had come down fast from Whiteball, with a maximum of 80 m.p.h., before entering a stretch of restricted speed beyond Cullompton; nevertheless, our start-to-stop time of 44 min made us 8 min late.

The station staff saved us a minute, but even with our now much reduced load of 260 tons, there seemed little prospect of recovery onwards to Plymouth with three permanent way slacks to observe, and a heavy stopping train just ahead. We observed the long 40 m.p.h. slack through Exminster and beyond, and following this a shorter one, to 15 m.p.h., and despite a smart regaining of speed took 12 min to cover the 8·5 miles from Exeter out to Starcross. Then, however, we found that with commendable foresight "The Devonian" had been held in the loop at Dawlish Warren to let us go ahead, and with this encouragement our driver and fireman set to work in earnest to wipe off the arrears of time. Even so, and knowing the calibre of No. 7036, I very much doubted if they would do it. It is one thing to run hard on a straightforward piece of road, but quite another to negotiate a stretch like the South Devon line, where it is sometimes difficult to avoid exceeding the speed limits uphill, let alone down.

To tell exactly how that lost time was entirely recovered save for a trifling 27 sec would take pages of detailed description; but it would savour more of expert enginemanship rather than a continuous exposition of locomotive capacity. Only for two short spells west of Newton Abbot was the engine put to it hard, on Dainton Bank, and from Totnes up to Rattery. As a sample of the grading involved the line between Newton Abbot and Dainton is shown to a large scale in Fig. 9; here, from passing through Newton at 30 m.p.h. this extraordinary 4 miles was covered at an average of 41¼ m.p.h. With cut-off advanced to 40 per cent the last full quarter mile on the bank, from Milepost 217½ to 217¼ was run at 29 m.p.h., but the engine slipped just on the crest of the bank, in the tunnel, and this final quarter mile became the slowest at 27½ m.p.h. On the Rattery Incline the engine was not worked so hard, as a thin rain was driving down from the moors and the rails were slippery. Elsewhere the power output needed from the engine was small, and the positive excitement of the run lay in one's appraisal of the driver's intimate knowledge of this winding road—just where he could put on something of a spurt, and where speed must emphatically be restrained. With clear signals throughout, but with the handicap of a permanent way check to 15 m.p.h. near Brent, he succeeded, and we ran into Plymouth with the clocks pointing precisely to 8 p.m.

"Taunton Castle" No. 7036—Summary, Paddington to Plymouth

Miles	Stage	Booked time	Actual time	Net time	Net average speed
		Min	Min sec		
142·7	Paddington to Taunton	148	142 45	142¼	60
30·8	Taunton to Exeter	36	44 03	33¼	55·1
52·0	Exeter to Plymouth	75	68 27	65	48·0

Our actual overall time from Paddington was 27 sec over the even 4½ h, but for all practical purposes we were "right time in"—a great effort. The run may be summed up in the table on page 538.

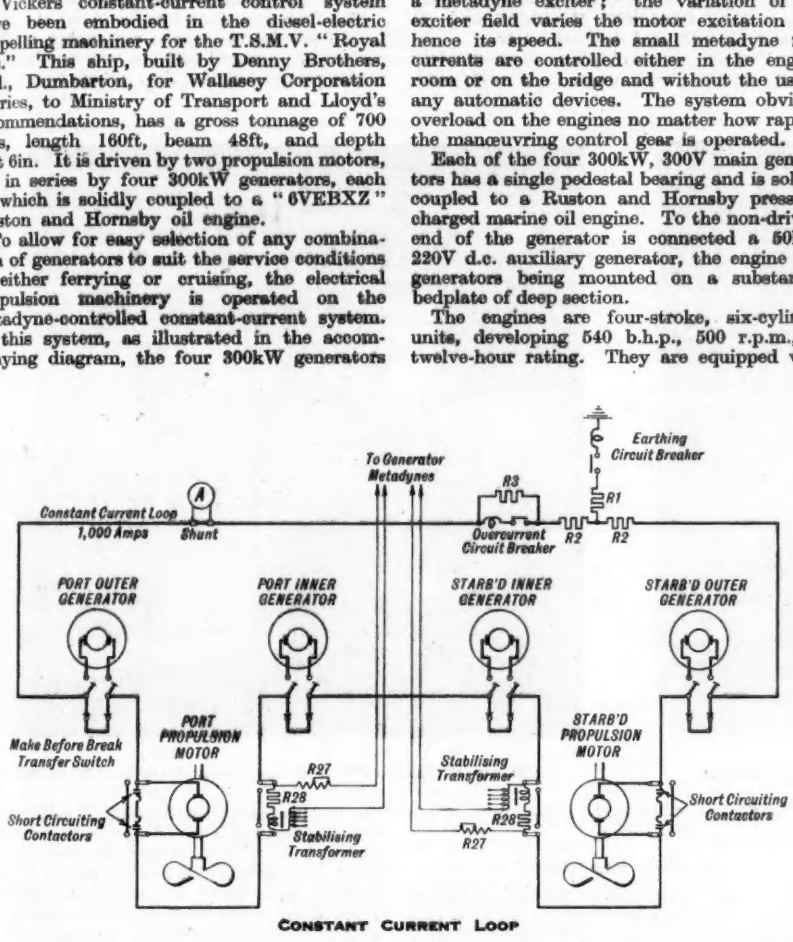
The total water consumption as indicated from the tender gauge was 7900 gallons, an average of 35 to the mile. We estimated that the coal consumption was about 4 tons, equal to about 40 lb per train-mile. This should be taken as indicative of the general order of things, rather than as a precisely measured quantity. But on whatever basis it is judged—whether on locomotive capacity or skilful enginemanship or on the fine spirit of enterprise and team work shown by the crew—this was an extremely fine run.

In conclusion, my thanks are due to the Railway Executive for permission to make these various journeys on the footplate.

Constant Current Control for T.S.M.V. "Royal Iris"

RECENT developments in the Metropolitan-Vickers constant-current control system have been embodied in the diesel-electric propelling machinery for the T.S.M.V. "Royal Iris." This ship, built by Denny Brothers, Ltd., Dumbarton, for Wallasey Corporation Ferries, to Ministry of Transport and Lloyd's recommendations, has a gross tonnage of 700 tons, length 160ft, beam 48ft, and depth 13ft 6in. It is driven by two propulsion motors, fed in series by four 300kW generators, each of which is solidly coupled to a "6VEBXZ" Ruston and Hornsby oil engine.

To allow for easy selection of any combination of generators to suit the service conditions of either ferrying or cruising, the electrical propulsion machinery is operated on the metadyne-controlled constant-current system. In this system, as illustrated in the accompanying diagram, the four 300kW generators



CONSTANT CURRENT LOOP

are connected in series with the two propulsion motors, each generator giving a rated output of 730 h.p. at 215 r.p.m., or 540 h.p. at 195 r.p.m., with a current of 1000A in the closed loop.

The generators are provided with special metadyne exciters, the main characteristics of which are a very small field current and a very rapid response rate, operating to produce the necessary voltage to maintain a constant level of current in the series loop, irrespective of the number of machines in circuit at any time. Any generator or motor can be cut out merely by short circuiting it. The act of short circuiting a machine causes a rise in current and the metadyne exciters immediately respond by reducing the generator field current, which, in turn, lowers the output voltage of the generators, thus restoring the current to its proper level. This method of controlling the generator fields makes it possible to limit their output and so prevent the system from being overloaded.

Each propulsion motor is also provided with a metadyne exciter; the variation of the exciter field varies the motor excitation and hence its speed. The small metadyne field currents are controlled either in the engine-room or on the bridge and without the use of any automatic devices. The system obviates overload on the engines no matter how rapidly the manœuvring control gear is operated.

Each of the four 300kW, 300V main generators has a single pedestal bearing and is solidly coupled to a Ruston and Hornsby pressure-charged marine oil engine. To the non-driving end of the generator is connected a 50kW, 220V d.c. auxiliary generator, the engine and generators being mounted on a substantial bedplate of deep section.

The engines are four-stroke, six-cylinder units, developing 540 b.h.p., 500 r.p.m., at twelve-hour rating. They are equipped with wet liners and solid forged steel crankshaft, the main bearings being steel shells lined with anti-friction metal. The cylinder-heads are separate iron castings, carrying overhead valve-gear and embodying easily removable valve guides. The pistons are of heat-resisting cast iron, the gudgeon-pins are fully floating and the connecting-rods are steel stampings, fitted with white-metal-lined big-end bearings, and chilled phosphor bronze small-end bushes. Accessories included with each engine comprise a "Streamline" oil filter, with electric heater, a hand-operated lubricating oil priming pump, a scavenge pump and feed pump.

Water circulation for the cooling system of each engine is maintained by two separate centrifugal water pumps, one for salt water and the other for fresh water; they are chain-driven from the engine crankshaft. Each engine is also provided with a British Thermostat alarm system, comprising contact-making thermometers and pressure gauges, arranged to operate an alarm in the event of failure of lubricating oil pressure, salt or fresh water supply or excessive temperature.

Engine speed is controlled by a centrifugal governor gear-driven from the crankshaft and, when both the propulsion motor controllers have been in the "stop" position for thirty seconds a special de-speeder device comes into operation and reduces the speed from 500 to 425 r.p.m., for reasons of economy and quieter running.

In addition to the auxiliary generators mentioned above, there are two auxiliary Ruston and Hornsby "5VPHZ" diesel engines. Each engine develops 80 h.p. at 800 r.p.m. and is connected to a 50kW, 220V generator. The six diesel engines are started from a compressed-air line of 300 lb per square inch, complete with three air bottles and a Hamworthy compressor, driven by an electric motor. When the six diesel sets are running the total available power for the 220V system is 300kW, the auxiliary generators operating in parallel under the control of automatic voltage regulators. The automatic regulators are necessary because of the change in speed of the diesels when the propulsion motors have been stopped more than thirty seconds.

Control Desk

The main propulsion control desk houses controllers for the propulsion motors, switches for the generators, a changeover switch for the two metadyne sets (one is a standby), a changeover switch from bridge to engine-room, and earth and overcurrent circuit protective breakers. The desk also embodies indicator and alarm panels for the various associated auxiliaries that are essential for the drive of the ferry, telegraph indicators, and indicating instruments showing the speed and s.h.p. of the main motors, the b.h.p. of the diesel engines and the current in the main loop. Finally, the desk also carries the push buttons for the automatic starters of the two metadyne sets and the four propulsion motor ventilating fans.

The bridge control is operated from three positions—port and starboard wings of the bridge and the wheelhouse—and consists of three controller heads similar to twin telegraphs. They are mechanically connected and geared to two controllers exactly similar to those fitted in the engine-room control desk. The controller heads also operate simultaneously the necessary transmitters for the engine-room telegraphs, so that, if it is desired to operate on engine-room control, the same operating handles are used as when on bridge control. Mounted on each controller head are two electrical indicators to show the propeller revolutions.

In connection with the 220V auxiliary supply, two switchboards are installed—one six panel and one four panel. Each board is a "dead-front" equipment. The six-panel board controls the six 50kW generators. Each panel is complete with circuit breaker, double-pole switch, ammeter, voltmeter, field rheostat and automatic regulator, indicator lights and discriminating relay. The four-panel board provides for the outgoing circuits and is split in two parts by a circuit breaker, one part containing essential circuits and the other non-essential circuits, so that if a generator becomes overloaded the non-essential circuits are tripped, leaving the essential circuits uninterrupted. The essential circuits include all items that are necessary for the propulsion of the ship, including navigating lights and steering gear.

All the engine-room auxiliaries are made by Drysdales and Co., Ltd., Sharples Centrifuges, Ltd., and Hamworthy Company, Ltd., the motors being made by the Metropolitan-Vickers Electrical Company, Ltd.

Installed symmetrically about the centre-line of the motor room are the propulsion motors, flanked by the two metadyne sets, with their associated stabilising transformers, and the ventilating fans. Both propulsion motors are water-tight in the lower half and the machines are fitted with rotatable yokes to give easy access to the bottom poles for replacement or repair.

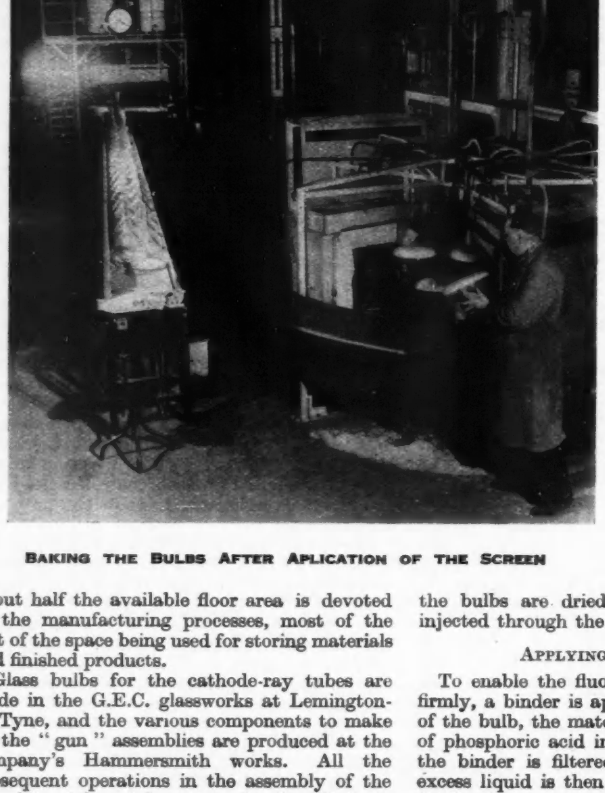
Each metadyne set consists of four rotating machines mounted in tandem on a common

bedplate, in the following order: two 4·5kW metadynes for the propulsion motors, a 29 h.p., 220V, 1450 r.p.m. driving motor and a 10kW metadyne for the generators.

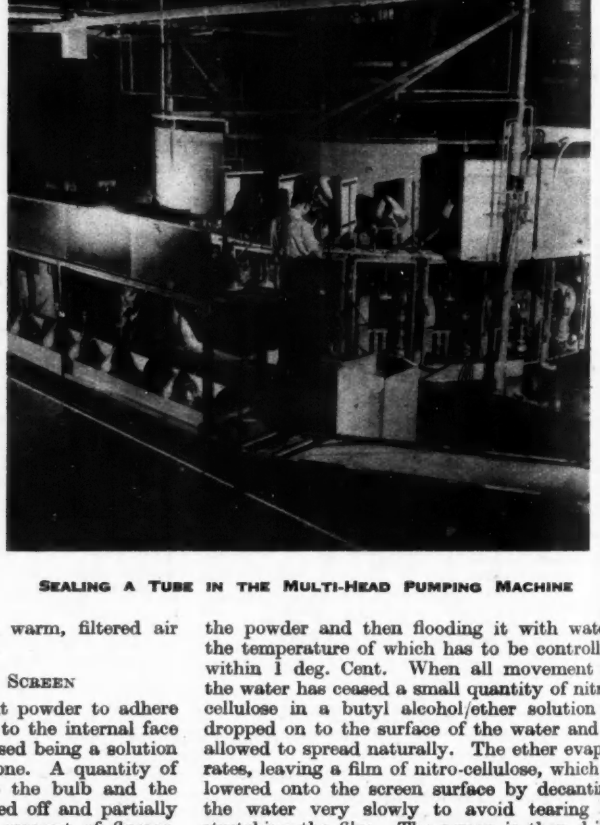
The short circuiting contactors for the propulsion motors and the automatic starters for the metadyne sets and fans are made by the Watford Electrical Manufacturing Company, Ltd., the fans themselves being made by Keith Blackman, Ltd.

A Cathode Ray Tube Factory

LAST week we visited a works in Perivale, Middlesex, where G.E.C. cathode-ray tubes for television are made. The factory itself was built in 1942 for the Ministry of Aircraft Production and was used as a shadow factory for manufacturing transmitting and receiving valves. Early in 1950 the General Electric Company, Ltd., took over the factory and began to re-equip it for the production of cathode-ray tubes. All the necessary machinery was designed and built by engineers of the Osram-G.E.C. group and it is worth recording that small-scale production began in July, 1950, only five months after the premises were taken over. At present only about half the available floor area is devoted to the manufacturing processes, most of the rest of the space being used for storing materials and finished products.



BAKING THE BULBS AFTER APLICATION OF THE SCREEN



SEALING A TUBE IN THE MULTI-HEAD PUMPING MACHINE

Glass bulbs for the cathode-ray tubes are made in the G.E.C. glassworks at Lemington-on-Tyne, and the various components to make up the "gun" assemblies are produced at the company's Hammersmith works. All the subsequent operations in the assembly of the complete tubes take place in the Perivale factory where present production is concentrated on 9in, 12in and 14in tubes, although future plans envisage the manufacture of 16in tubes and other sizes as may be required.

The production of cathode-ray tubes for use in television calls for the co-ordination of a number of techniques from the chemical, precision engineering and glassworking industries; it also involves the introduction of processes that are peculiar to the manufacture of these tubes. First, the main raw material is a lead glass with high electrical insulation. Secondly, the bulb must be of suitable dimensional tolerances and of sufficient strength to withstand, with a high factor of safety, atmospheric pressure when evacuated. Special care is required to ensure that the face of the tube is free from blemishes and, after a careful annealing treatment, each bulb is pressure tested with water applied externally at a difference in pressure of 2 atmospheres.

At the Perivale works the first operation on the glass bulbs is a very careful washing. To ensure the necessary surface cleanliness, the washing process is divided into six stages, which are performed, in succession, on a semi-automatic machine. The six stages are: (1) a preliminary rinse with tap-water; (2) washing with a weak solution of hydrofluoric acid; (3) a rinse with hot tap-water; (4) washing with a hot solution of caustic soda; (5) a cooling rinse with tap-water, and (6) a final rinse with cold distilled water.

The whole process takes approximately twenty minutes and, when it is completed, the bulbs are dried with warm, filtered air injected through the neck.

Applying the Screen

To enable the fluorescent powder to adhere firmly, a binder is applied to the internal face of the bulb, the material used being a solution of phosphoric acid in acetone. A quantity of the binder is filtered into the bulb and the excess liquid is then drained off and partially dried. Next a controlled amount of fluorescent powder, chiefly zinc sulphide, is placed in a glass air-gun and is sprayed uniformly over the plasticised inner surface of the glass face of the bulb, after which the bulb is rotated in a machine and at the same time is tapped gently to free the excess powder. Finally, the bulb is revolved and the entire inner surface, excepting the screen, is cleaned to remove unwanted powder.

This method of applying the screen is a simple one, but it demands careful control of the grain size of the powder and its "free flowing" properties. This control, together with colour control, is achieved by routine chemical and physical inspection of all the materials used. After the powder has been applied the bulb is placed in a rotary oven, as illustrated, and given a ten-minute baking at a temperature of 350 deg. Cent., to fuse the phosphoric acid binder. To avoid cracking the glass the heat cycle is spread over forty-five minutes. During baking the evolved vapours are removed by blowing filtered air into the bulb.

Aluminising

Then follow the preliminary steps leading to the all-important aluminising of the rear surface of the screen, which is done mainly to prevent "burning" of the fluorescent powder by negative ions, and to reflect the fluorescent light towards the viewer. The difficulty of the aluminising process will be appreciated when it is realised that the aluminium film must be thin enough to allow electrons to pass through (actually the film is about a quarter-millionth of an inch in thickness) and must only cover the rear surface of the grains of powder if fluorescence is to take place at all. The process involves the distillation of aluminium and, if the vapour were allowed to condense in a straightforward manner, the aluminium film would be deposited all over the grains and the fluorescence would be nil.

The first step, therefore, is to fill the voids in the powder, so that a reasonably uniform surface is presented and the way to the front of the grains blocked. This is done by washing the powder and then flooding it with water, the temperature of which has to be controlled within 1 deg. Cent. When all movement in the water has ceased a small quantity of nitro-cellulose in a butyl alcohol/ether solution is dropped on to the surface of the water and is allowed to spread naturally. The ether evaporates, leaving a film of nitro-cellulose, which is lowered onto the screen surface by decanting the water very slowly to avoid tearing or stretching the film. The screen is then dried and inspected by transmitted light and a graphite coating is applied internally to complete the circuit between the anode and the side contacts.

Now follows the aluminising operation, in which the bulbs are mounted in a multi-head machine and a high vacuum is created by mercury diffusion pumps backed by an oil pump. At the end of the pumping operation a spiral of pure aluminium wire is vaporised electrically within the bulb and the metallic vapour condenses on the inner surface of the screen. Elaborate electronic equipment has been developed to control the thickness of the layer; it consists essentially of a thermionic oscillator, which beats with the output from a standard oscillator. The frequency of the standard is chosen so that a zero beat frequency is obtained when the required thickness of metal is deposited, (see THE ENGINEER,

April 6th, 1951, page 443). The bulbs are then passed to an inspection cabinet, where they are placed under a medium vacuum to check the electrical continuity of the graphite coating with the side electrode and to inspect the screen for defects by exciting it with a Tesla discharge.

Simultaneously with the processing of the bulb, the electrodes are assembled on jigs. Throughout this series of operations great precision is required and two typical examples may be quoted. The aperture of the modulator is held to a tolerance of 4/10,000th of an inch and the electrode has to be flat within 2/1000th of an inch. Again, the modulator is spaced with respect to the cathode by mica washers and the spacing has to be within 8/10,000th of an inch if the grid-base characteristics of the tubes are to be uniform. Because mica cannot be obtained to close limits of thickness, the required overall thickness is obtained by sorting the mica washers into a series of groups and obtaining the desired value by the selective assembly of two, three or four washers.

After the "gun" has been assembled it is checked electrically for continuity and insulation and is finally washed in alcohol, and sealed into the bulb.

Sealing and Pumping

The "gun" assembly is sealed into the neck of the bulb on a rotary, multi-head pumping and sealing machine; during the operation the bulb is filled with dry nitrogen at atmospheric pressure, to guard against oxidation of the electrodes. To prevent strains being introduced into the glass during sealing, the bulb leaves the machine for cooling in a series of temperature-controlled chambers and, finally, in a draughtproof box.

The pumping machine, which is illustrated herewith, has positions for twenty-four tubes; it is semi-automatic in operation and works on a two-hour cycle. A two-stage mercury pump backed by a rotary oil pump, is used to obtain the high vacuum required. Pumping takes two hours and one tube is taken off the machine every five minutes. The final stage in evacuation before sealing is accompanied by the fusion of a "getter," which is preplaced in the electrode assembly. The tube is then sealed and removed from the pumping machine and the tubes are capped, aged and tested.

In the ageing process an initial h.t. voltage of 2kV is applied to the anode and is slowly increased to 10kV over a period of thirty minutes. During this period the beam current is gradually increased and the screen is scanned to prevent "burning."

Testing of the finished tubes is divided into several stages, the aim being to ensure that a defective tube or one which departs from the published characteristics, does not leave the works. In the initial testing stage every tube that is produced is checked on a production test table designed to reproduce the working conditions of a television receiver. The tests include, for example, measurement of the width of the trace and measurement, by photoelectric means, of screen brightness. In addition, one tube in every ten is carefully checked for all characteristics and the results plotted statistically. The tubes are then stored in cartons for two weeks and at the end of this time every tube is again tested under "receiver" conditions, after which it is finally packed, ready for dispatch. In addition to all these tests, there is a system of "quality control," in which tubes are taken at random from the final stages of production or from stock and are given careful tests, which include, for example, measurement of vacuum, peak emission and tests in actual television receivers. Production trends can thereby be detected before the normal limits of manufacturing tolerance have been reached.

Correction.—The Candy Filter Company, Ltd., has drawn our attention to an error in the Article "A South African Water Supply Scheme" in our issue of April 20th (page 522). The area of each filter is, in fact, 1089 square feet, instead of 33 square feet, as stated.

The British Electrical and Allied Manufacturers Association

The fortieth annual report of the British Electrical and Allied Manufacturers Association (Inc.), covering the activities of the association during 1950–51, was published at the end of last week. In a general review of the year's work the report points out that, with a labour force of over half a million and an output of over half a milliard pounds sterling, the electrical industry to-day ranks among the five leading British industries and is the country's second largest exporting industry. From a pre-war total of £23,000,000 the value of electrical exports grew to £140,000,000 in 1949 and, in 1950, reached a total of £159,000,000, which represents nearly three times the pre-war volume. This increase of 14 per cent between 1949 and 1950 was more than double the estimated target increase. In 1950, as in 1949, electrical exports continued to be made up of about 38 per cent electrical machinery and 62 per cent electrical goods and apparatus. The Commonwealth remained the best customer and took about 60 per cent of all Britain's electrical exports. Within the Commonwealth, Australia was the largest buyer, followed, in order, by South Africa, India and New Zealand. Among foreign countries the three largest buyers were the U.S.S.R., the Netherlands and Eire, followed closely by Sweden, Argentina and Egypt. Although exports to hard currency countries, particularly U.S.A. and Canada, were not large, the totals were increased, those to Canada rising by 50 per cent during the year.

The report goes on, however, to point out that the future is unusually obscure because of the shortages of non-ferrous metals and other important raw materials and the effects of rearmament. To help in the maintenance of raw materials supplies, B.E.A.M.A. is compiling a census (based on returns from its members), giving the total requirements of some seventy different materials. This census is intended to form a basis for discussion with the Ministry of Supply and the relevant trade associations dealing with the materials.

Generating Plant Production

Referring to the lack of adequate electricity supplies, the report states that the resulting heavy loss of industrial production, equivalent to tens of millions of pounds a year, is a matter for constant concern. The report then goes on to say: "the present shortage of electricity is still so often mistakenly attributed to lack of generating plant that, once again, your council take the opportunity of stating that the manufacturers of turbo-generating plant and electrical equipment are in a position to provide, in addition to meeting export requirements, up to a third more than the British Electricity Authority can order." This surplus manufacturing potential, the report points out, is a result of the limitation imposed on the Authority by the Government's capital expenditure programme. Accordingly, the Association (B.E.A.M.A.) made continual representation during the year, "insisting that the programme of the British Electricity Authority for the provision of new power stations and ancillary equipment should be substantially increased to meet the essential needs of the nation".

Dealing more specifically with the achievements of the past year, the report shows that the manufacturing industry is now reaping the benefit of extensions to productive capacity that were made in the immediate post-war years. Thus, whereas the plant delivered ex-works was about 1100MW in 1948 it was nearly 2000MW in 1949. A further increase was achieved in 1950, when deliveries ex-works totalled 2400MW, of which about two-thirds was for the British Electricity Authority and the remaining 800MW was mainly for export. According to the report, therefore, "although 1600MW was delivered ex-works for the B.E.A., the actual plant commissioned only amounted to 1034MW." The manufacturers' viewpoint as expressed in the report is that the turbine makers could provide the B.E.A. with 2000MW of plant per annum but the Authority's programme only calls for about 1500MW a year over the next five years; accordingly, it is felt that the programmes should be increased to at least 1800MW annually.

Railway Electrification

Referring to other results of restrictions on capital expenditure, the report deplores the depressing effects that are being felt in railway electrification, particularly in view of the spectacular success of the Liverpool Street-Shenfield electrification. Since this electrification (quoting from the report) "loaded coach train miles increased by 33 per cent, passengers journeys by 49 per cent and passenger receipts by 42 per cent, despite the fact that the railway runs parallel to a well-served main road for over fifteen miles." The report then goes on to quote a statement by Mr. Barnes, the Minister of Transport, to the effect that to serve the increased number of passengers by buses on a reconstructed main road would have cost tens of millions, against the £8 million spent on the railway electrification.

Education

Education occupies a prominent place in the report, which contains references to the endowment by the Association of a chair of Electrical Engineering at Cambridge University. Reference is also made to the B.E.A.M.A. group training scheme, whereby a number of firms form a group to provide selected graduates with training in various branches of the industry, "so that, at the end of two years, each student will have received comprehensive training comparable with that provided by the larger composite firms." Members participating in this group training scheme have already offered to provide facilities representing an intake of about thirty students a year. The report also refers to the Athlone fellowships, under which a number of awards will be made annually by H. M. Government for the post-graduate training, in this country, of engineering students from Canada.

Finally, the report surveys the year's activities of the various council committees, sections and technical committees, dealing with a variety of matters, including research and development, production efficiency and standardisation, marketing publicity and contract conditions.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

ALUMINIUM AND ALUMINIUM ALLOY SECTIONS

No. 1161 : 1951. The British Standards Institution has issued a revision of B.S. 1161, Aluminium and Aluminium Alloy Sections, which was first issued in 1944. The standard has been extended to cover additional sizes of sections and include equal angle sections, ¾in by ¾in to 9in by 9in; unequal angle sections 1¼in by 1in to 12in by 6in; channel sections, 3in by 1½in to 12in by 4in; "I" sections, 3in by 1½in to 12in by 6in, and "Tee" sections, 1in by 1in to 9in by 9in. Most manufacturers can supply all sizes and many are able to make larger sections than those listed but these have not been standardised. Price 5s., post free.

STEEL TUBES FOR AUTOMOBILE PURPOSES

No. 980 : 1950. This is one of a series of standards for steel tubes for general engineering purposes and supersedes B.S. 5009 : 1924, "Steel tubes for Automobiles."

Three types of steel tube are covered—cold drawn seamless, electric resistance butt-welded, and cold drawn electric resistance butt-welded. Within each type a number of grades are specified. In the case of cold drawn seamless tubes the range extends from soft mild steel to high tensile and stainless steel.

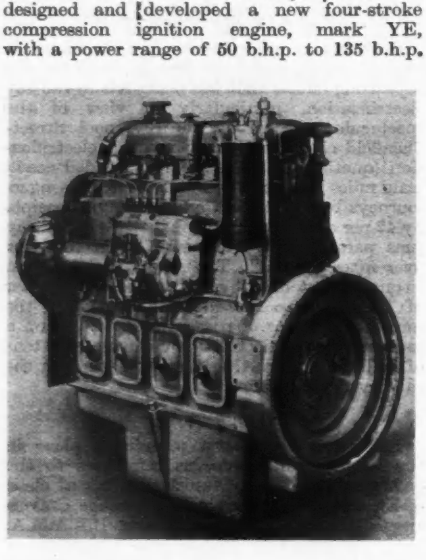
The specification lays down the mechanical properties and chemical composition for each grade of tube and for butt-welded tubes provision is made for an hydraulic test if required. Dimensional tolerances, including straightness, are specified.

A table at the end of the standard gives a useful summary of the chemical compositions and mechanical properties of the complete range of tubes.

Price 2s. 6d., post free.

A Four-Stroke Oil Engine

THE present-day demand for a heavy duty oil engine with a low power/weight ratio continues to be pressing and to satisfy this demand Ruston and Hornsby, Ltd., has designed and developed a new four-stroke compression ignition engine, mark YE, with a power range of 50 b.h.p. to 135 b.h.p.

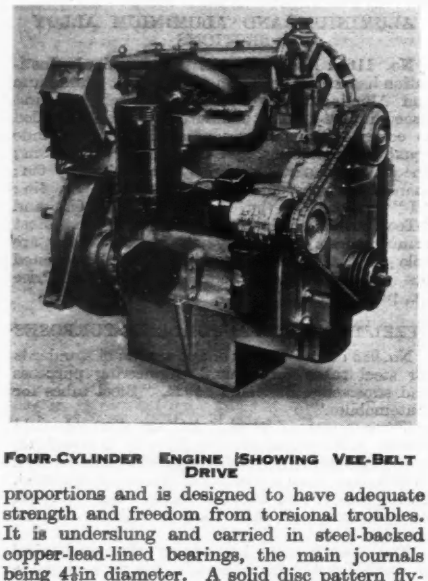


FOUR-CYLINDER ENGINE SHOWING FUEL PUMP

The general appearance of the four-cylinder engine can be seen in our illustrations.

By the term "heavy duty" is implied the application of power for driving industrial machinery, marine propulsion, excavators, locomotives, cranes and for the generation of electricity. For work of this kind it is recognised that a heavy and robust engine is necessary to ensure long life and dependability.

The crankcase and cylinder block are of monobloc construction and are cast in high quality close-grained iron. To give adequate access to the connecting-rods and crankshaft bearings, easily removable inspection doors are provided. The cylinder heads, which are readily removable, are of high-grade cast iron and carry the overhead inlet and exhaust valves, together with the valve gear and injectors. Efficient water-jacketing ensures cool valves; they are of heat-resisting steel and have pressure lubricated rockers. The crankshaft is a steel stamping of generous



FOUR-CYLINDER ENGINE SHOWING VEE-BELT DRIVE

proportions and is designed to have adequate strength and freedom from torsional troubles. It is underslung and carried in steel-backed copper-lead-lined bearings, the main journals being 4½in diameter. A solid disc pattern flywheel is provided and the housing has a standard S.A.E. No. 0 attachment to suit standard generators and friction clutch drives. The design of the housing is suitable for both rigid side bearer mounting or three-point suspension. The connecting-rods, which are designed for easy removal through the cylinder bore, are "H" section steel stampings with pre-finished steel-backed copper-lead big-end bearings and phosphor bronze small-end bearings. Hollow crown pistons of low-expansion aluminium silicon alloy are fitted and, in common with high-speed engine practice, have three pressure rings and two scraper rings, one above and one below the fully-floating gudgeon-pin. The crown of the piston forms an open direct-injection combustion chamber, ensuring ease of starting and low fuel consumption.

A monobloc vertical helix pump, having a separate unit for each cylinder, supplies fuel to multi-hole nozzle-pattern injectors. On the suction side of the fuel pump is a fuel filter, consisting of a two-stage fabric element. A centrifugal governor is mounted directly on the pump housing and a hand-lever, operated control gear is provided. Fitted in the sump is a submerged gear pump, which is equipped with suction and full-flow filters and is chain driven from the crankshaft. The lubrication system is so designed that it will function when the engine is operating at a maximum angle of 1 in 4. Engine cooling is by an assisted thermo-syphon or forced circulation system and is thermostatically controlled. Immediately the engine is started the centrifugal water pump begins to operate; it is belt-driven from the crankshaft. The single multiple vee-rope system also drives the starting dynamo and radiator fan. A 24V system is employed for engine starting but, as an alternative, distributor and air valves in the cylinder heads for air starting can be provided. Viewed from the flywheel end, the direction of rotation of the engine is anti-clockwise.

The engine is designed to use distillate fuels, having a specific gravity not greater than 0·88 and a viscosity of not more than 45 seconds at 100 deg. Fah., Redwood No. 1. Four, five and six cylinder engines are available. The four-cylinder model develops 50 b.h.p. at 1000 r.p.m., 62·5 b.h.p. at 1250 r.p.m., and 75 b.h.p. at 1500 r.p.m. Over the same range of revolutions the five-cylinder engine gives 62·5 b.h.p., 78 b.h.p., and 94 b.h.p., respectively, while the six-cylinder engine develops 75 b.h.p., 93·5 b.h.p., and 112 b.h.p. The engine ratings as given are for temperatures up to 85 deg. Fah. and altitudes up to 500ft and at 1800 r.p.m. the three engines have a maximum intermittent rating of 90 b.h.p., 112·5 b.h.p. and 135 b.h.p., respectively. Excluding extension shaft, outer bearing or other accessories, the weight of each engine is approximately 2100 lb, 2470 lb, and 2850 lb. Regarding the dimensions of the engines, all three have the same height and width, namely, 4ft 2⅜in and 2ft 5½in, while the overall lengths are 3ft 10⅛in, 4ft 5⅞in, and 5ft 0¼in, respectively.

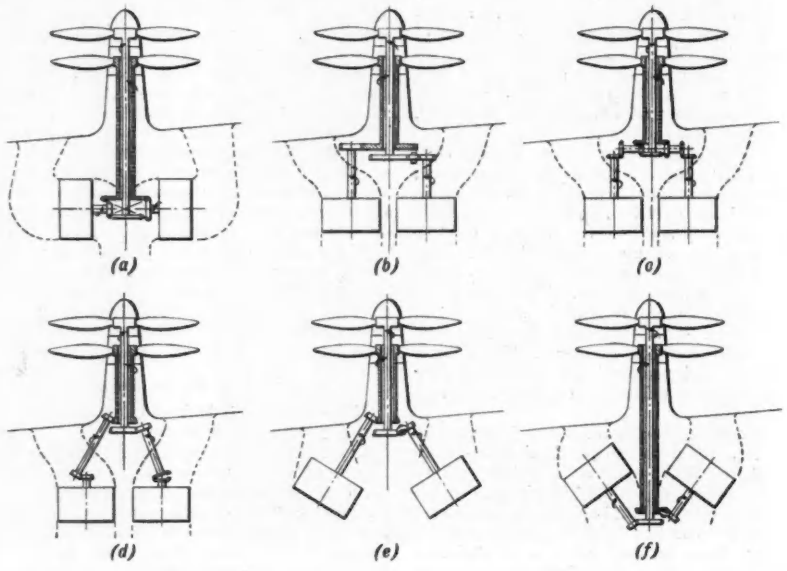
The Twin Centaurus Power Plant for the Bristol "Brabazon"*

By J. L. NORTON†

No. I

FOR a non-stop service between London and New York, it was considered that an aircraft of approaching 250,000 lb all-up weight would be required to carry a payload great enough to ensure an adequate return on the capital expenditure necessary for a stated traffic density.

So large an aircraft required great power for its propulsion and this meant large engines. At the time the Bristol "Brabazon" design was prepared the only power unit of suitable size appeared to be the Bristol "Centaurus." This is an eighteen-cylinder, air-cooled, sleeve-valve radial engine, which produces 2500 h.p.



(*a*) Co-axial engines
(*b*) Parallel engines, spur drive
(*c*) Parallel engines, bevel drive
(*d*) Parallel engines, "V" drive
(*e*) "V" drive
(*f*) Reversed "V" drive

FIG. 1—*Six Engine Lay-outs Investigated*

at 2700 r.p.m. for take-off. A total of eight of these engines was required.

GENERAL CONSIDERATIONS

As aircraft size increases, engine diameter also increases, but at a lower rate. This is due to several factors, such as the increasing number of engines and the increasing ratio of horse-power to diameter. In the "Brabazon," the wing thickness is, in fact, greater than the diameter of the engine. It seemed logical, therefore, completely to submerge the engines within the wing profile and thus avoid the drag associated with the normal nacelle installation.

Eight engines spread along the wing leading edge, would not be conducive to aerodynamic efficiency, and it was agreed that the engines should be grouped in pairs, each pair driving two co-axial propellers.

The next consideration was how best to arrange the engines and six different lay-outs

*Abstract. Institution of Mechanical Engineers, April 20th.

†Special Projects Engineer, The Bristol Aeroplane Company, Ltd. (Engine Division).

received serious consideration (Fig. 1). From the aspect of mechanical design there was a tendency to favour the parallel engine arrangement. On the other hand, since cooling of the engines had to be paid for in terms of power or drag, it was important to keep the air ducting as simple and unrestricted as possible. Therefore it was of advantage to avoid such obstructions in the cooling-air stream as would be caused by large gearboxes, &c.

In regard to weight, every pound saved in airframe or engine-installation weight meant that the operator could carry 1 lb more payload. It is illuminating to calculate the revenue value, to the aircraft operator, of this saving over a period representing the useful life of the aircraft, say, eight years. Assuming that a passenger plus baggage weighs 250 lb, and that the single London-New York fare is £150 sterling, the cost per pound per trip is £150/250, or twelve shillings. Now a fair figure for aircraft utilisation is 3000 hours per year, and the journey distance is 3443 miles. At 230 m.p.h. average speed this corresponds to 200 single journeys annually. The total revenue which the operator would receive for each pound of passenger weight for the period stated is, therefore, £200 × 8 × (12/20) = £960, say, £1000 in round figures.

It was ultimately decided that the "V" arrangement of engines as shown in Fig. 2, would give the best compromise.

General Lay-out of Power Plant

Fig. 2 shows the lay-out of the power plant in the wing. Two "Centaurus" 20 engines are housed separately in fire-proof cells in the leading edge of the wing. Their centre lines converge forward at an included angle of 64 deg., and the engines are supported on the box-section cantilever structure, which separates the two engine cells. This structure, carried by the wing spar, is formed by a pair of nose ribs, together with the upper and lower wing skins. Suitable reinforcement is incorporated in the design to provide for all the loads imposed by engine and gearbox weight, propeller thrust and weight and propeller gyro loads; the last occur only with one engine out of action.

The forward extremity of this cantilever is closed by a diaphragm, to which is bolted the propeller "stalk." The dual-reduction gearbox is secured within this monocoque structure, and flexibly jointed primary-drive shafts convey the power from the two engines.

The propellers are carried on concentric shafts extending forward from the dual-reduction gear and, to minimise aerodynamic interference, are situated some distance ahead of the leading edge. The forward ends of the shafts are supported in a bearing carried by the closure of the propeller "stalk."

Engine Mounting

The traditional method of mounting a radial engine in an airframe is through the medium of a stiff rectangular section ring secured to the engine crankcase bolts. A triangulated tubular structure is attached to this ring and terminates in four fixing points at the aircraft structure. The whole arrangement is, in general, symmetrical.

The departure from established practice embarked upon for this aircraft, was necessary to avoid any adverse effect on primary-drive shaft alignment due to wing flexure or propeller stalk "nodding." It was decided, therefore, that both engines, together with the dual-reduction gear, should be grouped as closely together as possible, thus forming, with the forward half of the cantilever structure, a compact unit which would be unaffected by wing deflection. This necessitated "picking up" each engine at the side rather than at the rear. From many alternative lay-out geometries investigated, the final choice was a structure with the minimum number of redundancies and using a three-point attachment to the aircraft structure. This design (Fig. 3) consists of a pair of tripods attached to the engine crankcase at their feet, and with their apices secured at points near the top and bottom respectively of the cantilever structure.

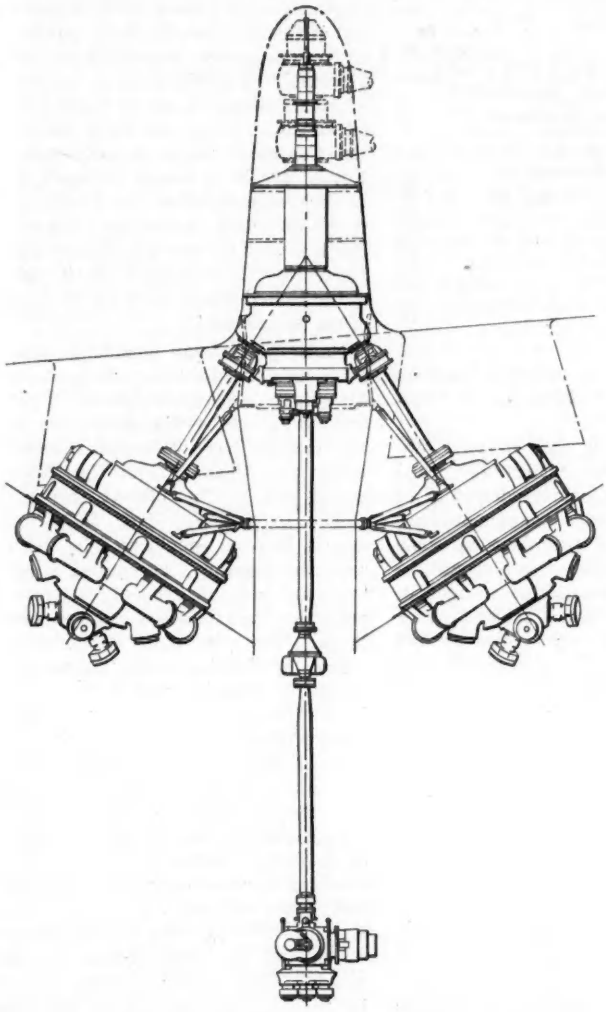


FIG. 2—*Lay-out of Power Plant in the Wing*

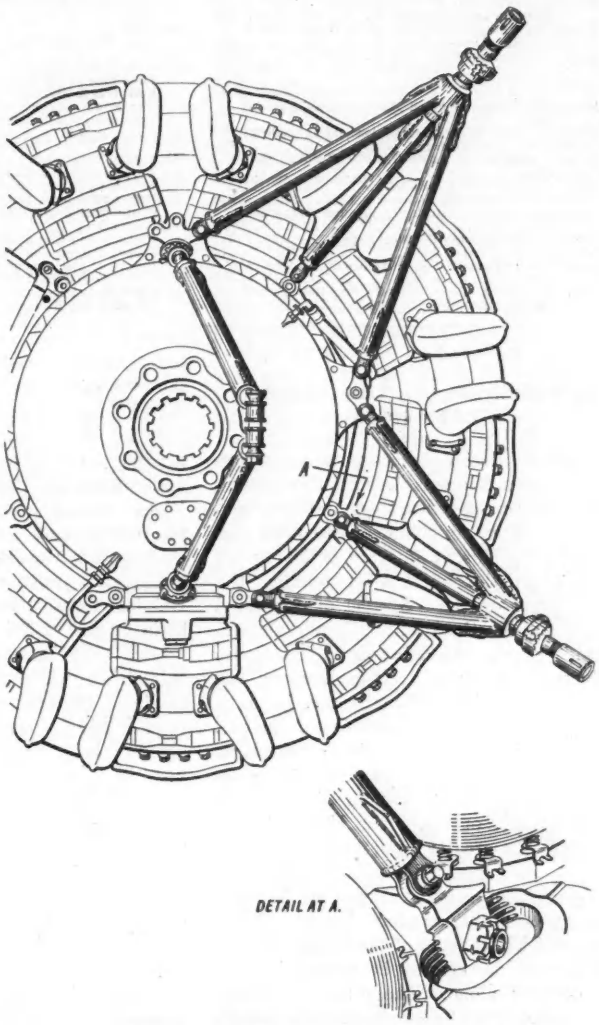


FIG. 3—*Engine Mounting, Brackets and Struts*

These tripods were designed to provide for all vertical and side loads and engine torque reaction. To accommodate fore-and-aft loads and to stabilise the assembly against pitching moments, two further tubes were provided, connecting top and bottom of the crankcase to a common point forward on the cantilever structure.

The weight of engine and accessories supported by this mounting is 3200 lb and, for this particular application, design for eight times this weight was necessary to cover the accelerations imposed during heavy landings. The material used in the construction of the engine mounting tubes is a chromium-molybdenum steel to specification D.T.D. 178 (now T.53). The end fittings are of a "40" carbon steel to specification D.T.D. 126 and they are welded to the tubes. The weight of the entire mounting, including bolts, &c., is 60 lb (compared with about 120 lb for a representative mounting of normal type). A load equivalent to an acceleration of approximately 15*g* was applied before failure took place.

(To be continued)

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DEPENDENCE ON THE UNITED STATES NAVY

IF nations decide to co-operate in resisting aggression, it seems they require a bewildering number of committees and commanders and deputy-commanders to co-ordinate their efforts. This, at any rate, is the impression left in the mind after reading the White Paper on the "System of Command Within the North Atlantic Treaty Organisation," which was debated in the House of Commons last week. It is, however, the naval section of the Paper which is particularly likely to disturb the British people. As one of the reasons for the appointment of an American admiral as supreme commander, Atlantic, it is pointed out that "the overall resources of the United States Navy are far greater than our own" and then it is suggested "only by a large deployment of resources can we hope to fight successfully another Battle of the Atlantic." The defence of the North Atlantic Ocean, that is, cannot be undertaken by this country alone. These are deplorable and—in the light of Government statements on the Navy before the Korean campaign—almost unbelievable admissions. Government spokesmen have said again and again in the House that all is well with the Navy, that we have the measure of the submarine menace and that our anti-submarine forces are stronger and better able to deal with enemy submarines to-day than they were in 1939. One remembers also that Britain and Canada bore the whole burden of the struggle against the U-boats in 1943, when the submarine war reached its climax and the U-boat attack was decisively broken. For the past 300 years the Royal Navy has safeguarded our country and our trade routes against combinations of strong naval powers and against many types of ships. But now, it seems, it is incapable of defeating the naval forces of one Continental and mainly military power, which is likely to use against us, at least on a large scale, only one type of vessel—the submarine! As Mr. Churchill pointed out in the debate, Russia has no fast capital ships, such as the "Scharnhorst," "Gneisenau," "Bismarck" and "Tirpitz."

It is, of course, true that modern submarines have a greater underwater speed and endurance than their predecessors of World War II. Moreover, we cannot share the complacent belief prevalent in some circles that the Russian Navy would be unlikely to prove a formidable antagonist. Russian naval forces have achieved very little in past wars, but naval strategy and tactics have been greatly changed by the submarine—particularly by the modern submarine. Submarine operations do not all require much training and experience at sea for their execution. The Russians are past masters in the manufacture of mines and it is not necessary that a submarine commander should have considerable technical skill to blockade our ports by laying magnetic and acoustic mines—mines which are difficult to sweep up but easy to lay, either from submarines or aircraft. Little more than a knowledge of navigation is required for a submarine to proceed submerged, using her schnorkel, to suitable positions for launching atomically charged guided V2 rockets on London and our industrial cities—a very worthwhile operation and possible in the early future if not in the immediate present. Even attacks on merchant ships can be carried out with relatively little skill if the vessels are inadequately escorted. A very large force of fast anti-submarine vessels is, of course, the effective counter, indeed, the only counter to the submarine danger, and it is presumably precisely because we have so few ships of this type that the Government has been obliged to admit in the White Paper our dependence on the great assistance the United States Navy might give us for the protection of our supplies of food and raw material. The White Paper cannot make pleasant reading for the Sea Lords of the Admiralty, though they must have concurred in it. Indeed, they could do little else, since it is not for the Board to decide whether or not we are to depend on the support of the United States Navy, but to implement the naval policy laid down by the Government, if satisfied with the financial provision for doing so. The Board's view on the naval situation at the present time—or, rather on what that situation should be under modern conditions—was no doubt adequately expressed by the Parliamentary Secretary to the Admiralty during the debate on the Navy Estimates. "There has been a profound change," said Mr. Callaghan, "in the strategy of the defence of these islands. The North Atlantic Treaty Organisation is a recognition of that change and of the fact that the Navy can no longer, on its own, prevent invasion from across the Channel." That is a frank statement to which no exception can be taken. Our own air and land forces and those of nations on the Continent would be involved should Russia decide to invade Western Europe. If they were defeated the Navy, by itself, could do little to protect these islands. But it is very far from an admission that the Royal Navy must depend on the assistance of the United States Navy for the protection of our sea routes!

Under present-day conditions attacks on this country need not be restricted to invasion by ship. Airborne divisions, V2 rockets and atom bombs launched from, should an enemy have occupied them, ports across the Channel and the North Sea would test to the utmost this country's ability to endure. Even these forms of attack, however, might well be endured by a stubborn people, determined at all costs to retain their freedom—at least for a time, until the United States came to our assistance. For the most rabid isolationist across the Atlantic must ultimately realise where his true interests lay, as he did in 1917. The atom bomb is newer and vastly more powerful than any other weapon but it is, in fact, no more than an additional danger to be dealt with in a total war. The 135,000 casualties—killed and injured—at Hiroshima seem a ghastly number out of a total population of 250,000 but by far the larger proportion were caused by blast and burns and only 15 per cent by radioactivity. With a good civil defence organisation and our brick houses and shelters and by taking proper precautions, it should be possible very greatly to minimise the effects of an atomic explosion. Moreover, there have been many improvements in anti-aircraft defence measures since the war and it will not be easy for attacking aircraft to reach their targets. On the other hand, without food or raw materials we could do nothing but surrender. It is an appalling thought that the Royal Navy, which has for generations kept the seas free for peaceful trade should no longer be able to safeguard our own necessities of life without assistance from America. In recent years, it is true, United States policy has completely changed but are we justified in assuming that it will never change again? Might not the Pacific area become, some day, more important to the U.S.A. than Europe? Can it be guaranteed that in no circumstances will the Americans revert to their former isolationist attitude? The present rearmament programme of twenty-four fast frigates and forty destroyers for conversion, to be completed by the end of 1955, would hardly have been adequate even if begun

five years ago, with a similar number of frigates added each succeeding year. The programme represents all the Government is prepared to do having regard to the maintenance of our peacetime economy and the rearmament needs of the Army and Royal Air Force. But it has been a very late beginning and if this once great Naval nation is to be free from the stigma of dependence on another for Naval protection, we should make still greater efforts, even at the sacrifice of our standard of living. British ship designers, builders and engineers are among the most experienced and efficient in the world and it should not be beyond their capabilities to design and produce in large numbers relatively small standardised vessels, simple to construct but with engine power for high speeds, for anti-submarine purposes. But to produce them in sufficient numbers and at a sufficient rate a special yard might need to be laid down and prefabrication methods might need to be adopted.

The Festival of Britain

ONE hundred years ago on May 1, 1851, a still youthful Queen Victoria and her much-loved Prince Consort drove through the streets to open a "Great Exhibition" in Hyde Park. The Prince Consort, through the judicious but energetic support he had given to the Royal Society of Arts and the organising committee, had done much to make the occasion possible. And it really was a very great occasion. For no such Exhibition had ever been held before. True, upon the Continent, there had been many national exhibitions. But in Britain, the most powerful and most industrialised part of the world, such exhibitions had never proved popular. Now, not only was a "Great Exhibition" being held in the heart of London, but it was an international, not merely a national affair. No less than forty different countries supplied exhibits. For it was considered that "whilst it appears an error to fix any limitation to the productions of Machinery, Science and Taste, which are of no country, but belong, as a whole, to the civilised world, particular advantage to British Industry might be derived from placing it in fair competition with that of other nations." The various products were shown in a remarkable building tall enough to enclose whole trees and sheathed in glass—*The Times* ungraciously called it a "monstrous greenhouse"—designed by Paxton, which was later, as the Crystal Palace, to become a landmark in South London; and the products of each country, as far as might be, were each set out in four divisions—raw materials, machinery, manufactured products and "sculpture and plastic art generally." It was hoped—in vain, we must assume, if we judge by what came after—that the show would help to raise the standard of British industrial design. But, in fact, it became an Exhibition exalting in particular the great material advances that had grown out of the Industrial Revolution, and since Britain had been the prime architect of that revolution, and since she was at that time still rising towards the zenith of her supremacy as the "Workshop of the World," though it was an international exhibition, it particularly emphasised the work of this country.

On Thursday next from the steps of St. Paul's, the King will officially open that "Festival of Britain" of which the South Bank Exhibition is the centre-piece. But that Festival, although it is held exactly a century after the Great Exhibition of 1851, is, in fact, a very different conception, as new in its own way as that first of all international exhibitions. It is linked with that former event only through the significance awarded in human affairs to the passage of a century. The Great Exhibition exalted in particular that material progress which was far more obvious in this country than elsewhere in the world. But these small islands, hugging the coasts of Continental Europe, could hardly be expected indefinitely to retain the lead in the production of material things that constellations of pioneers in scientific discovery and in engineering and industrial skills had temporarily given them. That lead has since passed from them. The nations now look not across the Channel with half-envious, half-critical wonder, but across the Atlantic, to see how phenomenally can productivity be raised and a nation be enriched thereby. But they still look to Britain as a leader in scientific and technical discovery. Moreover, in the last hundred years the people of this country have lost the confidence the Victorians had that they were on the way to discovering all Nature's secrets and that the process of discovery and use must necessarily be good for the human race. Britain has experienced two World Wars that have stressed not only the need for material strength, but the need for moral stamina, too. We have seen new political systems grow up rapidly like weeds, to command the support of millions of peoples and to become antagonistic to and envious of institutions that we hold dear. We have begun to understand better that, whilst adding immeasurably to the material wealth of the world through our discoveries and through the freedom with which we have taught other peoples or let them develop what we might well have developed ourselves, we have also shown to the world the value of our concepts of freedom of speech, thought and action, forbearance and tolerance, concepts the seeds of which are to be found far back in our history. In short, we appreciate better to-day than a century ago that there is a high value to be placed not merely on the material achievements of our nation, but also upon that "British Way of Life" of which we are so shy of speaking.

It was the genius of such men as Newton, Newcomen, Watt, Trevithick, Arkwright and many many others that made the great material advances emphasised by the 1851 Exhibition possible. But how came it about that so large a proportion of those whose names had become world famous were British? And how is it that these islands have continued right up to the present day to produce such men in profusion? It will, we think, seem to many when they have had time to think of what the Festival will show them, that the very growth of engineering, the wealth of scientific and technical discovery made in this small atom of sea-girt ground off the coast of Europe has been, and continues to be, the flower of the concept of freedom, a concept that made Englishmen, Scotsmen, Welshmen and Irishmen and all men of whatever nations who lived within our shores, fearless in setting forth new ideas and in criticising old ones; that, in fact, our way of life and our practical genius for tolerant living proved rich soil in which to plant the seeds of science.

Some such idea, we think, must have inspired the organisers of the Festival. For it is to be a very different affair from the Exhibition that it commemorates. During the Festival it will not be only Britain's record of material achievement in the last 100 years that will be on show. The whole of Britain, its countryside, its customs, its sports, its laws, its arts, its ways of Government are to be open for the examination of the visitor in addition to its industries and its scientific and technical learning. That conception is as novel in our age as was that of an international exhibition a century ago. The South Bank Exhibition, though it is the focus of the Festival, though it will attempt within the narrow confines of 27 acres to present the visitor with an overall impression of British life and British discovery is in reality only a small part of the whole. It will be accompanied by numerous other special exhibitions. In Scotland there will be one, devoted, appropriately to its situation in the midst of that country's industrial area, to "Industrial Power" at the Kelvin Hall, Glasgow. In Edinburgh's Scottish Museum the other side of Scots' life will be shown in an Exhibition devoted to "Living Traditions," and dealing with architecture and crafts. In Wales the "Welsh Industries Fair" will demonstrate all aspects of Welsh life and achievement, and in Northern Ireland there will be a "Farm and Factory" Exhibition at Belfast. Back in London an exhibition at the Science Museum will concentrate on the growth of man's understanding of the nature and structure of matter, a study to which so many famous scientists in these islands have made remarkable contributions. In the East End the rebuilding of a "blitzed" slum area in Poplar provides a novel "live" exhibition of British architecture, and at the Victoria and Albert Museum there will be staged a show commemorating the 1851 Exhibition. In addition, the Festival Ship "Campania" will carry to ten ports in the United Kingdom exhibits stressing in particular the maritime aspects of British achievements, and an "Exhibition by Land," to be transported by lorry from town to town will epitomize in little the story told by the South Bank Exhibition. The Church, the Theatre, the Films Industry, Music and the Arts generally will all contribute in their own ways, and all over the country cities, towns and villages are planning in one way or another to celebrate the Festival. As an information leaflet issued in connection with the Festival puts it, "for five packed months Britain will be at home to the world."

Engineers and the Festival

It is within the framework of that nation-wide conception of the Festival that engineers—and this journal with them—must play their parts. Modestly we need to acknowledge that in the actual living of civilised life, an emotional rather than a materialistic business, engineering plays but a small part, except to engineers. But indirectly—and we may justly take great pride in it—modern civilised life is so founded upon the work of engineers that scarcely a part of it could survive without their support. The point is duly recognised in the South Bank Exhibition, where three large buildings are to be concerned almost wholly

with the work of engineers, whilst in many others, also, their work will be strongly represented. For without machine tools, without power, light and heat, without modern rail, road and air transport, without ships, without ports, without water supplies, irrigation, sewerage, &c., modern civilisation could not survive. The discoveries of science, illustrated under the great dome on the South Bank, have immense value as contributions to human knowledge. But without the work of engineers few of those discoveries could be put to material uses. Nor, indeed, could a number of them have been made without the application of engineering knowledge and techniques in the construction of the delicately accurate instruments, from giant telescopes, synchrotrons and nuclear reactors, to small devices for minute measurement, through the use of which they were made.

But it is not only materially that civilisation owes a debt to scientists and to engineers who have applied the science. The products of engineers have had an influence upon and have enlarged the opportunities of artists. We do not refer here only to the greater perfection with which artists' tools and instruments and materials can be made; nor even to those new mediums for artistic expression and performance, films, the radio and television. There is a more direct link. Primarily engineering products, their forms dictated by the need to conform with natural laws, if efficiency is to be high—such products, for instance, as aeroplanes and turbo-generators, cars and ships, dams and sea defence works—have heavily influenced the design and form of many other useful and ornamental objects and have caused artists to appreciate in a way never so much appreciated before, the interest to be found in the relationships between smooth, curved surfaces, and in "functional" design. Nowhere are the consequences more obvious than in architecture. Up till a hundred years or so ago builders had among important materials of construction only wood that could be trusted to act safely as a tension member. All others had to be in compression. To-day, they have steel and reinforced and pre-stressed concrete. Aluminium, combining strength with lightness and rigidity introduces qualities still more new. Engineers have provided more than new materials alone. They have worked out and passed on to architects theories of stress and strain that have made it possible to use the newer materials with an economy beyond the dreams of earlier builders. The revolution being wrought in architectural design thereby—a revolution based upon the work of engineers, but conceived by architects—is well revealed by the buildings in the South Bank Exhibition. There architects and artists have been allowed a freer hand than could have been permitted them elsewhere to use these new materials as they liked, to use cantilever constructions, to carry wide, flat or curved structures on thin supports, to make walls of glass, to set supports diagonally instead of vertically, and in the Dome of Discovery to show how aluminium can permit the erection of a structure whose immensity cannot be properly appreciated until it is entered. Maybe not everyone will like the results. But the influence is undeniable. The pavilions on the South Bank and the great dome itself are structures built under the influence of engineering principles, not by traditional methods. The 1851 Exhibition was housed in a building constructed upon novel principles of deep interest to engineers. It is a link with that century-old Exhibition that the exhibits on the South Bank should be similarly housed in structures that add to the interest of the show for engineers.

1. Chicheley Street Gate
2. Information and Post Office
3. Fairway Café
4. Station Café; Escalator Hall for Underground below
5. The Land of Britain
6. The Natural Scene and The Country
7. Minerals of the Island
8. Power and Production
9. The '51 Bar
10. Sea and Ships
11. Dome of Discovery
12. Transport
13. Regatta Restaurant and Embankment Gate
14. The Skylon
15. Nelson Pier
16. Administration Block
17. The People of Britain
18. The Lion and the Unicorn
19. The Unicorn (Café)
20. Television
21. Telecinema
22. Locomotive Exhibit; Turntable Café below
23. Police and First Aid
24. Homes and Gardens
25. Courtyard
26. Administration and Staff Canteen
27. Royal Festival Hall
28. Seaside
29. 1851 Centenary Pavilion
30. Shot Tower
31. Waterloo Bridge Gate. The New Schools and Design Review below
32. Harbour Bar
33. Health
34. Thames-side Restaurant
35. Sport
36. Rodney Pier

PLAN OF SOUTH BANK EXHIBITION

The South Bank Exhibition

The South Bank Exhibition is not a trade fair. What is shown there is not for sale; nor will orders for goods be taken there. Information services, however, will be available to put prospective customers into contact with firms and organisations likely to be interested. What is shown on the South Bank has been carefully selected to reveal the historical contributions of this nation in the development of modern knowledge and modern civilisation, and to show the best of present-day British products. Nor is the Exhibition a technical one in the sense that the Engineering and Marine Exhibition to be held in September at Olympia is technical. The South Bank show is designed to appeal to the general public, not to specialists alone; to show to the people of this country and to the many visitors expected from abroad what Britain has achieved in the past and, even more, what it is achieving now.

A plan of the Exhibition accompanies this article. The site of the Exhibition, it will be seen, is divided by the Hungerford railway bridge. Two "sequences" of exhibits have therefore been arranged, one upstream and the other downstream of that bridge. The "Downstream Sequence" is concerned with the life of the people of Britain, its characteristics and traditions, homes, gardens, schools, health, sports, &c., and has, therefore, little direct engineering interest. It is the "Upstream Sequence" that engineers will primarily want to visit. Here will be found the following sections, the numbers against which refer to corresponding numbers on the plan.

5: *The Land of Britain.*—This section will introduce the whole of the "Upstream Sequence." It will give a picture of how the British Isles were formed, the origins of their natural wealth and their varied landscape.

6: *Country.*—To introduce this section there will be displays showing how the wild life of Britain varies from one area to another, the interdependence of animals and plants, and how man has modified the landscape. This will lead into the section which will be concerned with rural life and agriculture, particularly present-day utilisation of the land, and the breeding of plants and animals. The parts played by scientific research and mechanisation in British agriculture will be given the emphasis they merit. Full use will be made of live exhibits, both stock and crops, which will be changed as the season advances. A final display will be concerned with forestry and British timbers.

7: *Natural Resources.*—This section will be concerned with British raw materials, resources of greater variety than can be found in any area of comparable size.

8: *Power and Production.*—This large pavilion will take the story from raw materials to finished products. It will display the harnessing of power, the uses and processing of metals, the structure of British industry and the role of research, design and management in the modern industrial organisation. The section will outline the wide scope and achievement of British industries not by the display of any one in its entirety, but by the selection of outstanding processes, machinery and techniques from several groups of industries. The section will close with displays of goods to show the range and high standards of quality and design of British manufactures.

10: *Sea and Ships.*—The exhibits here will be varied, ranging from marine engines and a ship-testing tank to small tackle. The

whole sea story, however, is too large for one building. Ship operating and handling will therefore follow in the next section, while discovery and research by sea will be found in its logical position in the Dome of Discovery.

12: *Transport.*—This section will be concerned with transport by air, road, rail and sea. There will be numerous full-size examples of contemporary locomotives, road vehicles, aircraft and ship equipment. Use will be made of working exhibits, including models of docks and airports. Prominent display will be given to British advances in telecommunications (radio, radar, &c.), which have important applications for transport operating. Broadcasting, television and cables, subjects to which British contributions are particularly notable, will be strongly represented.

11: *The Dome of Discovery.*—The story to be told in the Dome of Discovery is British pre-eminence in discovery and exploration, not only by land and sea, but into the very nature of the living world and the universe. Thus, ranged alongside the achievements of such men as Cook and Livingstone, will be displayed the discoveries of British scientists such as Newton, Darwin, Faraday, Thomson and Rutherford, without which so much that is illustrated elsewhere in the Exhibition would not have been possible. One section will display the latest knowledge of the structure and nature of matter, culminating in a display of nuclear energy. Others will be concerned with land, sea and Polar exploration, Inner Space, Outer Space and the living world.

In all sections it will be made clear how the initiative in exploration and discovery remains with the British, who continue their researches aided by new ideas and new tools largely provided by scientists and engineers.

In a series of articles beginning in next week's issue, we shall endeavour, not to describe the Exhibition as a whole, but to pick out items of interest to engineers for particular mention. Many of the products to be shown are not new. Few, if any, have been made specially for the purposes of the Exhibition. Most of the engineering products, indeed, have already been described in this journal. But for the convenience of readers who intend to visit the Exhibition or who want to know what is there, we shall not hesitate to describe such products again. We cannot hope to mention everything of engineering interest that will be found in the show. But we hope, at least, to say something about all the major items.

The South Bank Exhibition will be open each weekday from 10.30 a.m. to 11.30 p.m., and on Sundays from 12.30 p.m. to 11 p.m. It will open on the afternoon of May 4th and will continue until September 30th.

Other Exhibitions

Besides describing selected exhibits from the South Bank Exhibition we shall also refer to the Exhibition of Science, South Kensington, which also opens on May 4th and continues to open daily 10 a.m. to 10 p.m. (Sundays 2 p.m. to 10 p.m.) until September 30th, and to the Exhibition of Industrial Power at Kelvin Hall, Glasgow, which opens on May 28th and ends on August 18th and will be open each weekday, but not Sundays, from 10 a.m. to 10 p.m.

Another Parallel with 1851

We cannot better conclude this our welcome to the Festival than by remarking upon another parallel with the events of 1851. A hundred years ago the decision to hold the Great Exhibition, the site chosen, the cost, and the design of the building, all aroused such widespread and heated criticism that at times it seemed scarcely possible that its promoters would be able to achieve their purpose. Since the announcement was made in December, 1947, by Mr. Morrison in the House of Commons that a Festival would be held this year, the Government and the organisers have had to face very similar criticisms. The critics have exclaimed at the cost and at the diversion of national effort at a time of economic difficulty; it has been claimed that the site chosen for the Exhibition is too constricted, and it has been prophesied that London's traffic conditions must become chaotic when the Exhibition opens. But when a week hence the Festival does open, we hope that the gloomy prophets will be proved wrong. We hope, too, that those who have, rightly or wrongly, criticised the decision to hold the Festival will cease their outcry. For after May 3rd Britain will be at home to visitors from all parts of the world. The time will then be past when it is possible without discourtesy to argue that we should never have invited them!

Obituary

R. A. STRUTHERS

We have learned with regret of the death, on April 12th, of Mr. Rupert Alexander Struthers, assistant chief engineer in the steam turbine engineering department of Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester. Mr. Struthers, who served with the Royal Engineers in the first world war, joined Metropolitan-Vickers in 1920 as a college apprentice and on the completion of his apprenticeship was appointed to the staff of the mechanical engineering department. From 1930 to 1933, Mr. Struthers was in Leningrad as a turbine engineer with the Metropolitan-Vickers Export Company and, on his return to this country, was for some time engaged on the development of the steam turbine locomotive, which the company equipped for the London, Midland and Scottish Railway. Since the formation of the steam turbine engineering department, of which he became assistant chief engineer in February, 1950, Mr. Struthers had been engaged in designing large steam turbines for many power station contracts in this country and overseas. Mr. Struthers was a Member of the Institution of Mechanical Engineers.

The Penmaenmawr Railway Collision Report

The report by Lieut.-Colonel G. R. S. Wilson, Chief Inspecting Officer of Railways, Ministry of Transport, on the Penmaenmawr railway collision, was published on Tuesday. The collision, it will be recalled, occurred at 3 a.m. on Sunday, August 27, 1950, between the "Irish Mail" from Holyhead to Euston and a light engine moving forward on the up line. The express was approaching Penmaenmawr Station under a clear distant signal, when the home signal was put to danger just before the engine reached it. The driver shut off steam, but was unable to prevent the collision. The acceptance of the express by the Penmaenmawr signalman was in order, but he had lowered the signals for it before the light engine had moved clear of the running line in the course of a shunting movement. Six people were killed and several were injured as a result of the accident. Five of the sixteen coaches of the "Irish Mail" were severely damaged. Colonel Wilson says in his report that the accident was brought about by the simultaneous failure of men in independent positions to appreciate their responsibilities. He considers that the signalman in the Penmaenmawr box was careless in assuming that the running line was clear upon the sole evidence of a whistle signal, but Colonel Wilson expresses doubt as to whether sufficient pains had been taken by the supervisory staff to explain clearly to a young and inexperienced man what were his responsibilities under an important safety rule, "having regard especially to its ambiguous wording." Responsibility for the accident, the report continues, must be shared in considerable measure by the driver of the light engine. His engine was detained on the up line for five or six minutes preceding the collision, but he failed to send his fireman to the box as required by rule, or, at the very least, to draw the signalman's attention to his position by a series of "pop" whistles. The new British Railways General Appendix, Colonel Wilson remarks, which will shortly be issued, will contain a standard code of engine whistles for communication between drivers and signalmen and other ground staff for a variety of operating purposes. But, he adds, as a general safety principle, it does not seem right that a whistle signal, however precisely codified, should be held to relieve a signalman of his obligations under the existing rule.

Science Museum Exhibition

There was opened, on Friday of last week, a special Festival Year exhibition, entitled "Science Museum: Past and Future," which will occupy the No. 1 gallery of the Science Museum, South Kensington, until the end of October. This exhibition is distinct from the exhibits of the Festival of Britain's Science Section to be housed in the new Science Museum buildings. The main purpose of the present exhibition is to display representative scientific and engineering museum objects, selected from amongst the great amount of material that has been in store for many years, for want of suitable accommodation, and which now includes some items never previously shown publicly. The exhibition endeavours also to portray the history of the Science Museum, and amongst the pictures displayed are three large works, one showing the original museum in 1857, a recent aerial photograph of the area now occupied by the museum, and an artist's impression showing the new designs envisaged for future development. Amongst the models selected are some of the earliest forms of mechanical power transmission equipment and others depicting later designs, along with some modern equipment. Other sections of the exhibition are concerned with early civil engineering, navigation and transport associated with the period of about the fifteenth to the eighteenth centuries, and there is a section on industrial chemistry, including a model of an ancient woad mill. Working models of nineteenth century fire-fighting equipment are displayed as is the Shand-Mason steam fire engine. It is hoped that much of these collections will occupy the new galleries now under construction. These galleries will incorporate the latest display methods, employing in particular the cyclorama wall display technique, within buildings from which all natural light is excluded.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

NOT A USUAL SORT OF JOB

Sir,—Referring to the letter from Solex Gauges, Ltd., in your issue of March 23rd, on the subject of calibrating teats, it strikes me that this is a job for the teats manufacturers. It is high time that, instead of selling teats with unknown openings, the makers sold them calibrated suitable for various ages of babies.

A. Blum

Middlesbrough, April 20th.

TWIN-SCREW LINER "OCEAN MONARCH"

VICKERS-ARMSTRONGS LTD., BUILDERS

GRAND ENTRANCE

SMOKE ROOM

GRAND LOUNGE

CORAL CAFE

T.S.S. "Ocean Monarch"

No. II—*(Continued from page 516, April 27th)*

Passenger Accommodation

The cabins for the 430 passengers are sited on the Sun, Promenade, "A" and "B" decks and also on the port side of "C" deck, abreast and forward of the engine and boiler casings. The principle underlying the lay-out of individual cabins is that of providing as many as possible to be convertible to sitting rooms, resulting in three styles of stateroom being available, although there are a number of variations caused by the availability of deck space. The cabins are arranged as one and two-berth rooms, with an additional berth being available. The problem of convertibility is solved by the extensive use of the combined bed-settee and the extra berth is provided by fitting a stowing and lifting bed, of sofa pattern, which is stowed away within the cabin bulkhead. This is so arranged that the amenities and shape of the room are not disturbed. With the exception of a few cabins on the promenade deck, which have baths, all staterooms have private toilet compartments containing a shower cubicle and washbasin. There are nine different schemes of stateroom decoration, consisting of polished hardwoods and dull-finished veneers, such as ash, ivory, sycamore and ice birch, and leather cloth, whilst the toilet compartments have walls of linette Formica in various colours. The furniture is of various matching timbers, including ash burr, French walnut, birds eye maple and sapele.

The principal public rooms are situated on the sun deck, with the Coral cafe forming the central feature. This room is of good size, having a 'tween deck height of 11ft 6in, and centres around a hardwood parquetry dance floor, about 34ft long. At the forward end is a raised platform set in a recess having a bevelled roof fitted with acoustical tiles and furnished with a grand piano and musicians' stands. The extreme outer sides are arranged under a low deck and form alcoves fitted with banquette seating. A curved decorative panel having at its centre engraved plate-glass sections, giving the impression of a fountain at play, screens the domestic service access. Double doors at each side of the band platform open on to wide corridors, which join an entrance hall and then continuing forward, lead, through quilted leather doors, to the smoking room. The centre space of this room is largely occupied by a bar and the wings are arranged for card playing. The wall facing the bar is decorated with a simple inlay depicting the ship's silhouette against an outline background of the islands of the West Indies.

Forward of the smoking room is the grand entrance hall, which is the main embarkation point. Two double glazed doors on each side give access to a sheltered weather deck and facing the lift well and forward stairway is a small information bureau, while a feature of the hall is the carved solid hardwood figures representing "Prospero" and "Miranda," from Shakespeare's "Tempest." The grand lounge is a spacious apartment, which extends from side to side of the ship, has a width of 72ft and takes the bow shape of the bridge front. Tall windows with transom lights largely fill the wall space, which is panelled in sycamore and prima vera, and over the marble fireplace is a lacquer picture in silver and gold, which is Chinese in character and represents an architectural garden scene.

The midship stairway and lift lead to a large square foyer on "B" deck, which is the principal assembly place for the dining saloon. The room is well furnished, with a number of informally placed table and seat groups, and is panelled in a simple Empire style. To starboard, anodised cast aluminium doors open on to two broad steps leading down to the deck level of the cocktail bar, which has walls lined with plastic sheeting, having as decoration two gilt carved plaques, representing Pan and a twin-tailed mermaid. From the foyer, wide arched openings lead aft to the dining saloon, which is 70ft long, occupies the full width of the ship and has a seating capacity of 255 persons, arranged at circular, rectangular and square tables. The centre of the saloon rises to a height of 15ft and at the forward end of the centre well is a veneered panel of aspen wood embellished with a carving in low relief, which represents "fruits of the earth" and embodies figures symbolic of plenty. Around the sides of the well are mural decorative motifs illustrating flesh, fish and fowl. Service is from the galley, situated aft of the saloon. through paired doors, which are hidden by cast and glazed ornamental silver-bronze screens.

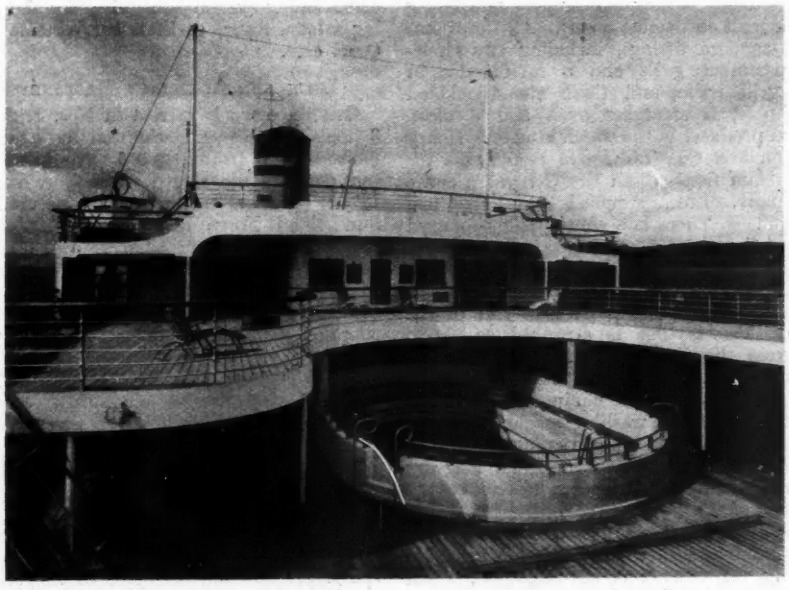
Further forward, on "B" deck," is the cinema, which has a seating capacity of 136 and is of narrow fan-shape in plan and two decks in height. The lower part of the walls is panelled in a South American wood, Courbariel, while the upper part is lined with perforated acoustical tiles. Access to the various decks is by way of two main stairways arranged around lift wells, which rise from "C" deck to the boat deck and there are entrance halls at each deck. In the forward entrance on the promenade deck is a wide-fronted shop, forward of which are the beauty parlour and barber's shop. The midship entrance on "A" deck is used for embarkation purposes and has a bureau and a number of telephone kiosks. All entrances are panelled in a simple manner and the stairways have figured birch above a dado of paroba, while the lift doors are of solid silver bronze. On the promenade deck the midship entrance has a special decorative feature of an inlaid marquetry wall panel designed, in symbolical form, to represent the Monarch of the Ocean. The lighting arrangements throughout the public rooms make considerable use of fluorescent tube of the cold cathode variety.

Situated aft, on the promenade deck, is the open-air swimming pool, which has a surge recess at each of the semicircular ends. The pool is overlooked and partially covered by the sun deck, which sweeps away aft in a wide curve to port and starboard. On the opposite page a number of illustrations show some of the public rooms.

A. McInnes Gardner and Partners were the architects, and the main contractors for the work were H. H. Martyn and Co., Ltd., Hampton and Sons, Ltd., and Frederick Sage and Co., Ltd.

Crew Accommodation

The captain and staff captain each have a suite of rooms on the bridge and the chief engineer has similar accommodation to starboard at the aft end of the house on the boat deck. The rest of the officers are comfortably housed on this deck at the forward end of which is a lounge for their use and their mess is situated aft on "A" deck to starboard. The crew's mess rooms are forward on "A" deck, their cabins are arranged forward and aft on "B" and "C" decks and a recreation space is provided at each end of the ship.



Swimming Pool and Sun Deck

Hotel Services

Immediately aft of the dining saloon is the well equipped galley, which is mainly electric and has a ten-oven island range, on either side of which are hot cupboards. To starboard is the bakery, equipped with double-deck baking and pastry ovens and ancillary fittings, such as a dough kneader, mixers and a roll machine. The space to port is sub-divided into the vegetable pre-

paring room, kitchen scullery, steam kitchen, fish kitchen, meal service room and fruit and still room. At the forward end

GALLEY

of the galley is the plate scullery and facing it the grill and coffee rooms. All the rooms have modern fittings, including two three-compartment grills and a salamander in the grill room, and three steam-jacketed stockpots, a steaming oven and a clean steam producer in the steam kitchen. Henry Wilson and Co., Ltd., was responsible for the steam fittings and the General Electric Company, Ltd., supplied the electrical equipment. There is a crew's galley forward on "A" deck.

At the aft end of "B" deck is a modern laundry, which is well able to meet the requirements of the passengers and of the ship. The lay-out is arranged so as to progress the work efficiently and Thomas Bradford and Co., Ltd., has supplied a full range of the latest equipment, including electrically-driven washing machines, hydro extractors, a two-roll ironing machine having steam-heated rollers 100in long by 24in diameter, and steam-heated rotary driers.

Mention has already been made of the two passenger lifts; there is also a lift fitted for the convenience of the engineers, which rises from "C" deck to the boat deck. Two other lifts transfer stores from the refrigerated compartments, one serving the main galley while the other supplies direct to the pantries on "C," "B," "A," promenade and sun decks.

All cabins have a telephone and the system is worked by a manual exchange situated in the "A" deck entrance. For the disposal of messages there is a pneumatic tube system, which operates between the wireless and radio-telephone offices direct to the Purser's office and the telephone exchange.

Ventilation

Throughout the vessel a complete system of Thermotank ventilation and heating, consisting of forty-four enclosed units, is fitted and is capable of maintaining a temperature of 70 deg. Fah. inside the ship, with the outside temperature down to 10 deg. Fah. In the staterooms control is by "Thermo Reg," while in the public rooms thermostats in each compartment control the temperature by actuating modulating motors. In addition, a special air-conditioning system is installed for the dining saloon, foyer, cocktail bar, cinema and Coral cafe.

Deck and Auxiliary Machinery

General cargo is carried in Nos. 1, 2 and 3 holds and 'tween decks, and for handling purposes two 10-ton, two 5-ton and two 3-ton derricks are rigged, which are served by six electrical winches—manufactured by Sunderland Forge and Engineering Company, Ltd.—of 3-ton capacity at 130ft per minute, two of which have remote control. For controlling the 2⅜in diameter "Tayco" cable, Clarke Chapman and Co., Ltd., has supplied electric capstan gear with warping heads to port and starboard, and for riding at anchor there are automatic bow stoppers. The capstan transmission gear and motor are mounted on "A" deck, the motor being rated at 160 b.h.p., at 400 r.p.m., and for cable duty a pull of 30 tons at 38ft per minute can be exerted, while for warping the pull is 10½ tons at 130ft per minute. Two warping capstans are placed aft on "A" deck, each having a motor of 60 h.p. at 830 r.p.m. and able to exert a pull of 7½ tons at 70ft per minute.

Brown Brothers and Co., Ltd., is responsible for the four-cylinder electro-hydraulic steering gear, which is powered by two 35 b.h.p. units, each driving a V.S.G. variable delivery pump and each capable of doing full duty. Telemotor control from the bridge operates the gear and there is hand control from the docking position aft. The semi-balanced rudder is supported by the steering gear maker's patent carrier and a small emergency steering unit is fitted to ensure there will be no interruption should the main units fail.

The refrigeration machinery supplied by J. and E. Hall, Ltd., is placed between the shafts in the space immediately aft of the engine-room. The main plant consists of three vertical twin-cylinder Freon 12 compressors, having stainless steel cleading and driven by 90 h.p. variable speed motors. One machine is coupled to the cargo and domestic services and is required to cool the cargo chambers of 17,000 cubic feet down to minus 5 deg. Fah. and ship's provision chambers of 13,000 cubic feet to temperatures suitable for the various commodities carried. The second machine takes care of the air conditioning system and supplies the necessary chill brine, while the third is cross connected to either system.

Two 40,000 gallons per hour Drysdale seawater pumps, five brine pumps and an ozone plant, which prevents cargo crosstaint, are included in the plant. "Axia" axial-flow propeller fans are fitted throughout the system.

Other equipment includes a "Duoflow" system of underwater sewage disposal, provided by J. Stone and Co., Ltd.

(To be continued)

The British Iron and Steel Research Association

THE seventh annual report of the council of the British Iron and Steel Research Association has just been published. It covers the year ended December 31, 1950, and the major portion of it is devoted to short descriptions of the principal investigations undertaken during the year by the various divisions and departments of the Association. The report notes that the widely drawn committee structure of B.I.S.R.A., consisting as it does of representatives of the iron and steel and other industries, universities and other research organisations, has exerted a constant pressure for new investigations and research on problems ranging from the supply and handling of raw materials, through the processes of iron and steel-making and metal deformation, to those more closely related to the user. The council's task, therefore, has been to ensure that the emphasis is in proportion to the requirements of industry and that priority is given to the most important projects.

The British Iron and Steel Federation is now preparing a second development plan for the iron and steel industry and B.I.S.R.A. is assisting by recommending special attention to technical matters, which can help to achieve the aims of the plan to improve quality and reduce costs. In this connection, fuel efficiency, new methods of agglomerating fine ores, the use of oxygen, high top pressure blowing, controlled distribution for blast furnaces, open hearth furnace design, increased mechanisation and improved works lay-out are all being studied. Work on the construction of the B.I.S.R.A. laboratories at Sheffield was started last year. A committee of the council is supervising progress and it is expected that the metal-working and chemical engineering laboratories will be finished by the end of this year and a block of general laboratories and offices during 1952. These laboratories will increase the Association's facilities for practical research on steel-making, metal-working, metallurgy, corrosion and analytical chemistry. Another step towards the establishment of B.I.S.R.A. in centres of the iron and steel industry has been the setting up of a laboratory, near Middlesbrough, as a base for field teams investigating some of the problems of iron-making and ore beneficiation. A pilot plant is being erected in the works of an adjacent member firm.

In what follows, we summarise some of the work done last year by certain divisions and committees of the Association.

Mechanical Working Division

The investigation of a new method of drawing wire without dies was resumed early last summer, experiments being devoted exclusively to hot stretching. The report says that this process is particularly suitable for producing base wire of a much smaller size than is possible by hot rolling. Even with the existing simple machine, devised by the Association and illustrated herewith, it has been found possible to reduce the area of 9 S.W.G. bright, hard drawn mild steel wire by 50 per cent in a single pass. By refining the control and design of the machine, it is believed that the reduction in each pass may be even greater. At present the speed is slow, though not much slower than that of continuous patenting or annealing.

The first aim of the research is to obtain sufficient data on which to base the design of a pilot plant, from which the economics of the process may be assessed. A further objective is to explore the possibilities of automatically controlling the gauge of the stretched wire and of controlling the heating to obtain desired metallurgical characteristics in the wire. The present machine consists of two capstans, one above the other, linked by a clutch and gearing. The incoming wire is wrapped several times round the top capstan and passes between two rollers, which serve as an electrical contact, down to the bottom capstan, which is earthed. The wire is heated by passing a heavy current through it. In the initial experiments the bottom capstan and part of the wire between capstans were submerged in water; in subsequent experiments a jet, concentric with the wire, has been substituted.

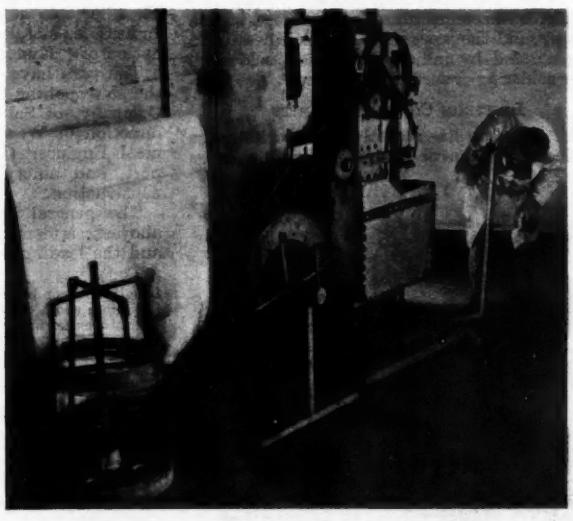
Plant Engineering Division

During last year an effort was made to complete as much as possible of the first stage of a comprehensive study of the handling of imported ore. The work has been guided by an advisory committee, organised jointly by the plant engineering and ironmaking divisional panels, which will report its findings to the executive committee of the British Iron and Steel Federation. A study of actual handling conditions has been confined so far to the unloading of ships at wharves; the problem of transport and storage between port and works stockyard having yet to be studied. The rate of ore discharge at six ports has been investigated in detail to determine factors affecting the turn-round time of ore ships, the ports having been selected to cover various sizes and classes of equipment and different working methods. The knowledge gained by this investigation, supplemented by information on the costing of unloading, is to be used to prepare estimates of relative operating costs of each class of equipment under various circumstances. A preliminary examination is also being made of methods of cleaning out the last of the ore from ships' holds by mechanical means, a part of the discharging operation which is at present slow and one requiring much manual labour.

An assessment has been made from tidal data of the extent to which ships of various tonnages can gain access to ten representative British ports and a comparison has also been made between the sizes of ships actually using the ports and the computed maximum sizes of ships which could enter them. This has shown that considerably larger ships could be used, if other conditions, such as chartering, were favourable. An attempt is being made, by a comparison of known performance figures in relation to ship design, to assess the suitability of various classes of ships for carrying ore and in this way it is hoped to specify the important points in the design of future ore-carrying vessels.

The work of the plant engineering division is assisted by four committees, dealing with mechanical, electrical and civil engineering and with fuel problems. The first of these—the mechanical engineering committee—has been examining, over a considerable period, the actual blast pressure and volume used in the blast furnaces at two works. This was part of an investigation into the blowing requirements of typical blast furnaces. It was found that wider limits had been specified for the pressure and volume than operations needed, the limits being governed not so much by the present requirements of the furnaces as by possible future demands. The investigation emphasised the difficulties of matching efficiently the blowing equipment and prime movers to a furnace which may radically change in practice and design during the life of the blowing plant.

One matter dealt with by the electrical engineering committee concerns problems associated with the rating of mill motors and their application to steelworks auxiliary drives. The committee had some discussions with motor manufacturers and users, as a result of which a "motor rating" conference was convened last November. The report says that this exchange of views confirmed the need for quantitative data on the alleged diverse duty cycles of motors for auxiliary drives as a first step towards the improvement of future motor selection. In addition, suggestions were made for two methods of motor rating—to take into account intermittent loading conditions—to replace the conventional one-hour rating, which was generally agreed to be unsuitable for the selection of mill motors. These proposals and the possibility of improved standardisation of mill motors, are now being examined.



Experimental Wire Stretching Machine

The work done by the civil engineering committee last year included a study of stresses in basic open hearth furnace arches. Earlier work had suggested the possibility of indicating which form of roof section should have the longest structural life. Improved equipment for measuring the compressive strain in furnace-roof arches has therefore been developed for installation in a silica furnace and sufficient units have been made to provide comprehensive measurement of the stress distribution across the arch ring of the furnace. The committee is making a review of the existing instruments for measuring various kinds of strain, such as static and dynamic and pure tensile, as part of a study on the possibilities of developing an improved recording strain meter, which would be portable and self-contained.

One recent activity of the fuel committee has been the development of a small-scale blast furnace gas cleaning plant, incorporating spinning disc water screen generators. The report records that preliminary tests on flue gas from a sinter plant have shown encouraging results and that the water and power requirements of the machine appear to be considerably less than those of a disintegrator. A larger unit, capable of cleaning 100,000 cubic feet of gas per hour, has now been manufactured and will shortly be installed for use with blast furnace gas.

Operational Research Section

The main resources of B.I.S.R.A.'s operational research section were occupied last year on the imported ore-handling investigation, which is being carried out in collaboration with the plant engineering and iron-making divisions and with assistance from the mathematics section. This project, the report says, has taken precedence over other work done by the section and, as a consequence, an investigation into handling and stocking materials in steelworks was interrupted. But it is hoped to resume that investigation shortly. An interesting new investigation, initiated last year by the operational research section, is one to determine the possibility of reducing scrap in rolling processes by more precise sizing in the early stages. So far this study has been limited to rail rolling but if it proves successful it is hoped to extend it to other products.

Conclusion

In presenting this brief—and by no means complete—review of the work of B.I.S.R.A., it is appropriate to recall that, although the Association was incorporated in 1944, it was not until the end of 1945 that the various investigations in hand were integrated as a comprehensive research programme. The succeeding five years have produced many examples of the growth of co-operative research in the steel industry. They have been described in a special report, entitled "Five Years of Co-operative Research," which was issued by the council of B.I.S.R.A. at the beginning of this year.

Finally, it is of interest to note that the council has now recognised the eligibility of Commonwealth steel-producing firms for ordinary membership of the British Iron and Steel Research Association. The South African Iron and Steel Corporation was the first to be elected and negotiations are pending with other firms in the Commonwealth. At the end of last year total membership in all classes was 300. Sir Andrew McCance, F.R.S., is president of the Association, the headquarters of which are at 11, Park Lane, London, W.1.

Remote Supervisory Control of Electricity Supply in Manchester Area.—On Monday, April 23rd, the electricity supply to what is probably the most highly concentrated industrial area in the world officially came under the control of a new common diagram supervisory system, manufactured by Standard Telephones and Cables, Ltd. The area—No. 1 sub-area of the North-Western Electricity Board—includes over 50,000 industrial consumers in and around Manchester and has the highest known load density in kilowatts per square mile. Supervision and control of the distribution network in this area is centralised in the Manchester control room at Dickinson Street, where the entire network is controlled by two "Standard" common diagram systems. The first, consisting of a system diagram and a control desk, covers the 6·6kV and 11kV networks. This system, installed some ten years ago for the control and indication initially of seventy-nine unattended substations, has the capacity for an ultimate total of 600 stations and at present controls 130, all from one central control room, and has been in continuous service since its installation. The second system covering the 33kV network was officially handed over for operational use on Monday. Both systems give finger-tip supervision of all distribution switchgear in the area.

A Showroom for Industrial Applications of Electronics

RECENTLY we attended the opening of an "industrial application showroom" which is intended to form a direct link between manufacturers and the research and development facilities of Philips Electrical, Ltd., Century House, Shaftesbury Avenue, London, W.C.2.

The showroom is housed in the same building as the research and development sections of the company's works at Brixton Hill, S.W.2. There the industrialist can discuss any particular problem in metal treatment with the company's research or production engineers; he can satisfy himself whether arc welding, resistance welding or r.f. heating will provide the most satisfactory solution; finally, he can see the work carried out by the different available processes. Another important service, which is attached to the Philips industrial application showroom is the company's arc welding school, where instruction is offered to welders—whether they be apprentices or skilled workers who want to learn new welding methods and processes, such as the application of contact electrodes and low hydrogen electrodes.

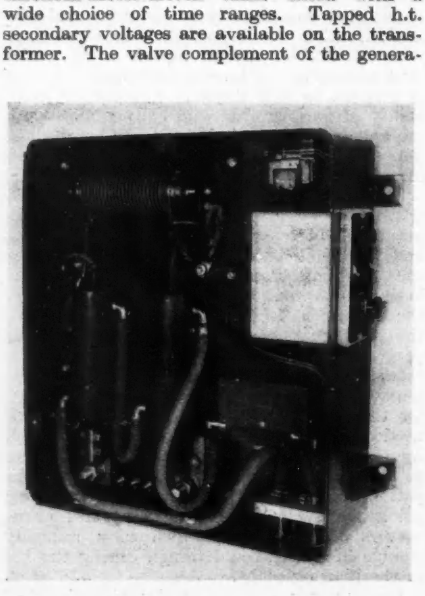
VALVE-OPERATED INDUCTION GENERATOR

Visitors to the showroom itself can see a number of examples of the company's products related to arc and resistance welding, high-frequency generators for induction and dielectric heating, equipment for power factor correction, rectifiers and electronic measuring instruments.

Among the new pieces of equipment seen during our visit to the showroom were a valve operated induction generator (type F18) for the controlled application of heat to metals, a range of ignitron contactor units for use with resistance welding plants and a double-gun mobile resistance welding unit. A brief description of these exhibits is given herewith.

The "F18" induction generator is a valve-driven equipment, rated for a continuous output of 10kW, with an intake of 18kVA from the three-phase, 380V-440V, 50 c/s mains. A general view of the equipment, which is supplied complete with mains circuit breaker and interference suppressor unit, is reproduced above. The generator operates at a nominal frequency of 400kc/s and the power factor is 0·9.

Points that may be noted about the design of the equipment are the built-in variable coupling transformer for on-load control of the output power and the inclusion of a synchronous-motor-driven timer fitted with a wide choice of time ranges. Tapped h.t. secondary voltages are available on the transformer. The valve complement of the generator consists of two oscillator valves and six rectifier valves.



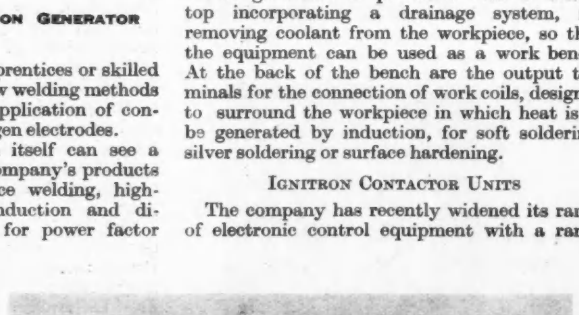
INTERNAL VIEW OF IGNITRON CONTACTOR UNIT

Meters for measuring anode current and r.f. output current are fitted between the process timer dial and the power control knob on the sloping control panel of the equipment. On the right of the panel are "on-off" push-buttons for mains supply and r.f. output, with a tell-tale indicator lamp for each. On the left of the panel are switches for the timer and for selecting operation by either push-buttons or foot switch.

The generator is provided with a bench-top incorporating a drainage system, for removing coolant from the workpiece, so that the equipment can be used as a work bench. At the back of the bench are the output terminals for the connection of work coils, designed to surround the workpiece in which heat is to be generated by induction, for soft soldering, silver soldering or surface hardening.

IGNITRON CONTACTOR UNITS

The company has recently widened its range of electronic control equipment with a range of ignitron contactor units for use with resistance welding plant. Through standardisation of timing instruments many combinations are available, using interchangeable timing instruments, thereby obtaining a sequence or cycle of operations such as pre-heat, weld, forge and repeat operation, all the sequences being preset from a master control instrument. The ignitron control unit on display in the showroom is illustrated herewith. It employs a pair of ignitrons capable of switching a line current of approximately 260A at a 50 per cent duty cycle. A water-flow switch is fitted as standard to all units and an electronic timer, giving time intervals from 4 c/s to 8 seconds, can be supplied as an integral part of the contactor unit if required.



DOUBLE-GUN MOBILE RESISTANCE WELDING UNIT

This kind of electronic contactor has some advantages over its mechanical counterpart; for example, it can break heavy currents quietly and effectively and, since there are no moving parts, practically no maintenance is required.

DOUBLE-GUN MOBILE RESISTANCE WELDING UNIT

This new equipment is based on the Philips mobile garage unit, and uses two guns connected in parallel, which can be used alternately. One gun is the normal hand-operated scissors gun and the other a hand-operated parallel action gun or "trombone." The unit is capable of welding up to 16 gauge material and incorporates a Philips resistance/capacitance timer for automatic control of welding time. The normal tip pressure exerted by the guns, which are fitted with 8ft of secondary cable, is 280 lb. The mobile unit requires a 400V, single-phase supply and has a maximum demand for 30A. Its compact and streamlined body is fitted with wheels and a handle, as illustrated, and, since its total weight is only 1¾ cwt, the equipment is mobile and can be moved freely in confined spaces.

Light Alloy Rolling Stock for London Transport

THE matter of weight saving is of special importance on railways with high-frequency services operating over short section. In extensive experiments in the construction of light rolling stock, London Transport has investigated the relative merits of mild steel, rustless steels and high-tensile aluminium alloys for coach construction. As a result of these investigations it was finally decided to use an aluminium-magnesium-silicon alloy (corresponding with the British Specification STA.7/A.W.10) for the load-carrying structure. The alloy was supplied by Imperial Chemical Industries, Metals Division, under their designation of "Kynal" M.39/2.

The cars have been designed and built by the Metropolitan-Cammell Carriage and Wagon Company, of Saltley, Birmingham, under the direction of W. S. Graff-Baker, Chief Mechanical Engineer (Railways) of London Transport, and ninety cars are at present under construction.

The general appearance of the new light alloy cars is identical with the latest steel coaches and the leading particulars are as follows:—

Overall length	51ft 1½in
Length between bogie centres	35ft 0in
Maximum width of body	9ft 8¾in
Width over solebar webs	8ft 4¾in
Height, rail to top of carlines	11ft 9¼in
Weight on rails	26·65 tons
Number of seats	40
Maximum passenger load (192 people) ...	12 tons

The stressed structure construction is similar to that previously standardised by London Transport for steel cars.

The standard design of steel bogies and wheels have one driving axle on each bogie, the bogie centre being offset towards this axle to give greater adhesion.

The weight of the alloy car body, complete with all equipment, seats, finish, &c., is reduced from 17 tons 16 cwt to 11 tons 5 cwt by the substitution of light metal for steel, a saving of 6 tons 11 cwt, of which 5 tons 18 cwt is contributed by body structure and 13 cwt by brake, door, electrical equipment, &c. A weight saving of 37 per cent is thus made for the car body, complete with equipment, and 20 per cent for the car, complete with bogies and motors.

The alloy car structure, an impression of which is given in the photographs we reproduce, generally follows standard practice, the monitors, purlins, cantrails, waistrail, solebar and longitude assemblies all being conventionally positioned. When initially studying the

design several points were borne in mind to decide the form of members to replace one or more steel sections. The considerations included the improved disposition of material afforded by the use of extruded sections, which allow more freedom in the design of profiles, and the increased moment of inertia required to obtain a stiffness and rigidity comparable with the values of the steel coach.

With the exception of a few members, such as body end corner pillars and certain other details, which are castings or forgings, the structure is built up from extrusions and sheet.

In the conventional roof certain improvements have been made possible by the use of extruded sections. The main longitudinal load-carrying members are roof cantrails and monitor rails run unbroken from end to end of the car, it being considered advantageous to allow as many longitudinal members as possible to run the full length of the coach to obtain the required stiffness under vertical loads.

The roof cantrail is used to locate the roof structure on bodysides, form a large rain-water gutter, locate the carlines or cross-members of the roof and form an attachment for the roof sheets. A monitor rail, which forms the other main longitudinal member in the roof is of intricate profile, being called upon to fulfil many subsidiary functions in addition to forming an important structural member. It is located immediately below the carlines, to give a direct run from end to end of the roof. Attachment is made to every carline by rivets passing through the two upper flanges of the monitor and the lower flange of the Zed carline. This arrangement allows the carlines to run in one piece for the whole span of the roof.

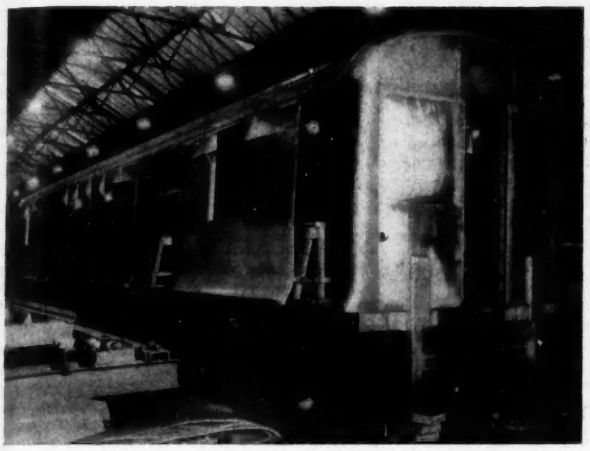
The monitor rail also provides means for the attachment of the vertical steel grab poles at doorways, the fixing of hand-grips for standing passengers, the formation of cable ducts, the location of fluorescent light fitting extrusions and the support of internal fittings and panels. Steel tubes or grab poles positioned at every windscreen and running vertically between the monitor in the roof and the longitudinal in the floor structure provide effective ties for the transmission of load between floor and roof. Between monitor rails the roof sheet is stiffened by "top hat" purlins, running in short lengths between carlines. The basic structure is thus formed by four main longitudinal members, crossed at short intervals by carlines and forming a stiff lattice work on which the roof sheets are laid and stiffened further by purlins. The ends of the roof are tied to the body ends by a stiff, centrally disposed, diaphragm plate, connecting the monitors with the end posts of the car, the whole being covered by a pressed canopy to form the required profile. The roof sheets between door pocket sections of the car are of 15 gauge, whilst those across double doorways, where loads are expected to be somewhat larger, are of 14 gauge.

Six sliding doors are provided per side on a non-driving car, four doors being positioned in pairs between bogie centres. Because of these wide doorways and two windows 5ft in length between double doorways, the coach body is resolved into two large beams formed by the longitudinal structures above and below these openings.

The basic structure of the bodysides is formed from extrusions and ⅛in thick high-tensile aluminium alloy sheet. The framing is formed between the body cantrail assembled in one length, and the skirting rail, an extrusion extending from the top of the solebar out to the "flare" of the body panels. Also running longitudinally between doors, just below the lights, is the waistrail, a stiff member between pillars, which effectively provides the upper boundary of the lower coach structure. A distance of approximately 30in between waist-rail and skirting is divided into three spaces by two panel stiffeners running between pillars. Thus, all expanses of bodyside panelling are supported by extrusions along the four edges, the larger panels being broken into small rectangles to increase the effectiveness of the sheet by greater stability.

While the "flared" body panels extend approximately 8in beyond the solebar, the pillars are attached directly to the solebar by taking them vertically from waist to solebar.

The centre pillars are riveted to the solebars, a pillar foot being formed by a short length of channel section, the web lying along the solebar with the flanges extending upwards and locating each side of the pillar extrusion.



LIGHT ALLOY COACH UNDER ERECTION

INTERIOR OF PARTLY ERECTED COACH

Sliding doors are accommodated in pockets in the large pillars at each side of the doors, so there is an external structure formed by the vertical pillar extrusions and skin and an internal one to support the interior finish and locate the windscreen structure.

The corners of the body are formed by "Alpax" castings having an average thickness of ¼in, which are attached to the floor structure and bodyside and end skins. These castings are assembled as part of the body end assembly.

The floor frame is formed by four longitudinal members approximately 7in deep. They form the solebars, which run unbroken for the full length of the car, and the longitudinals, which run in one length between bolsters. The longitudinals are continued from bolster to headstock with a somewhat heavier section. In this way the bolster is made an extremely stiff member extending between solebars and the longitude section stiffened at the ends, where shocks from the coupler are highest.

The headstock is formed by a stiff extrusion of roughly channel section profile and the whole of the end structure is strengthened by a large gusset plate of ¼in thick plate, extending for the full width of the floor and 3ft towards the bolster. Transverse members of the floor structure run for short lengths between the longitudinal members. Where heavy equipment is to be carried, additional cross members of "Z" section run in one piece between solebars, beneath the longitudinals. The riveted body bolster is formed from angle extrusions and flat plates into a box section, the depth at centre pivot being 11¾in with ½in thick angles and cover plates and webs of ⅜in plate. At solebars the bolster depth is nearly 7in. Corrugated section floor sheets are made from 16 gauge sheet, the corrugations being laid across the car.

We are informed that full-scale vertical and horizontal loading of a completed car structure has not yet been undertaken, but a series of loads was applied to an 18ft length of the car, incorporating a large centre window and one of the double doors.

Metallurgical Topics

Hydrogen Embrittlement: Effect of Rate of Strain

THE embrittling effect of hydrogen is observed in many different kinds of steel and in a large variety of circumstances. It is clearly revealed by tensile tests, and the effect on tensile properties is amply demonstrated in the work of Andrew and his collaborators, to mention one major research. The property measured in the tensile test which is most sensitive in revealing hydrogen embrittlement is reduction of area. In both carbon and alloy steels there is a steady decrease in reduction of area (at first almost linear) as the hydrogen content increases.

Apart from researches dealing with the general problem of hydrogen in steel, there are numerous reports of small investigations which record the behaviour of some particular product that becomes enriched in hydrogen under some special conditions, such as hot acid pickling or cathodic embrittlement of mild steel. One such investigation is that of J. B. Seabrook, N. T. Grant and D. Carney,[1] dealing with

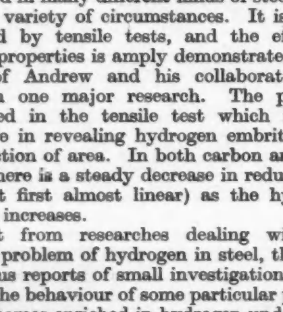


FIG. 1—*Effect of Rate of Strain on Reduction of Area in Tensile Tests. All Specimens Charged with at Least 6 P.P.M. Hydrogen (Seabrook, Grant and Carney)*

hydrogen embrittlement of steel containing carbon 0·19, manganese 0·40, sulphur 0·036, and phosphorus 0·012 per cent, and this is of special interest because it deals with the effect of rate of strain on the indications of tensile tests made on hydrogen-embrittled steel. A $\frac{7}{16}$in diameter hot-rolled steel rod was machined to tensile specimens, $\frac{1}{4}$in diameter and 1in acting length, and they were cathodically charged with hydrogen. No permanent damage was experienced by the metal, which reverted to its original properties when the hydrogen was reduced to normal proportions. The properties were dependent on the amount of hydrogen actually present in the test specimens. The effect of hydrogen on the tensile strength was of a minor character. The true stress-strain curves of the original steel and of specimens charged with six parts per million of hydrogen were parallel as far as the less ductile specimen went, and coincided to within about 3 tons per square inch; and there was no appreciable increase in hardness, but elongation and reduction of area were greatly diminished. At about 6 p.p.m. hydrogen (6·7 c.c. per 100 g.) the reduction of area, originally about 60 per cent, had fallen to 20 per cent, and lower figures were not obtained even with three times that amount of hydrogen. In the course of twenty-four to seventy-two hours the hydrogen diffused out from specimens which had contained upwards of 6 c.c. per 100 g, and reductions of area of 50 per cent were obtained with hydrogen contents of about $1\frac{1}{2}$ c.c. per 100 g.

Rate of straining in tension of steel specimens charged with more than 6 c.c. per 100 g had a marked effect on reduction of area. At very low rates of strain, and over a range up to and including those usually employed in tensile testing, the reduction of area remained unchanged at about 20 per cent. As the speed of testing was increased to very high rates (5in to 10in per inch per minute) the reduction of area increased and at a rate of 10 min^{-1} it reached 40 per cent, the same value as in steel containing about 2 c.c. per 100 g (Fig. 1).

[1] American Institute of Mining and Metallurgical Engineers, Technical Publication 2960E, *Journal of Metals*, November, 1950, page 1317.

The explanation put forward by Seabrook and his co-workers is that, to have its embrittling effect, atomic hydrogen must have time to diffuse in the strained steel and combine to form molecular hydrogen in the imperfections in the lattice structure opened up by straining. With very rapid straining there is insufficient time for diffusion to take place. This suggests an explanation of why hydrogen embrittlement has not been detected in notched-bar impact tests, and indicates an important factor which must not be overlooked in assessing the effect of hydrogen on the mechanical properties of steel.

The Sigma Phase

THERE has now been published in the form of a 204-page book (price 2.50 dollars) a full report of the Symposium on "The Sigma Phase," organised by the American Society for Testing Materials last year. It consists of eleven papers dealing with many aspects of the subject and illustrating the high importance which a study of this phase has reached since its discovery about twenty-five years ago. In those days its existence was regarded in some quarters as doubtful, and the technique of identifying it had not been worked out. Later, its identity was firmly established, and the conditions of its formation were determined in chromium steels, in some chromium-nickel steels, and in chromium steels containing small amounts of other elements. It appeared at one time to be a constituent of academic rather than of practical interest. It was not encountered in the ordinary stainless or austenitic corrosion-resisting steels then in production, though it was recognised as a possible constituent of the high-chromium, heating-resisting steels. There was a lull in the interest taken in the sigma phase for some years, followed by a resumption of intensive study of the subject when it was realised how greatly its presence might affect the hardness, ductility and resistance to corrosion of the ferrite-austenite (molybdenum-bearing), corrosion-resisting steels, and might also influence the mechanical properties of the heat-resisting steels that were being developed. Not only in America, but in this country, notable contributions have been made to both these aspects of the subject, and also to the elucidation of the crystal structure and the equilibrium conditions under which sigma and allied phases may occur in alloys for corrosion resistance and for high-temperature service.

THE A.S.T.M. SYMPOSIUM

Identification of the Sigma Phase.—Several papers communicated to the symposium dealt with the technique of identification of the sigma phase. A critical review of the X-ray diffraction data showed the existence of phases crystallographically identical with sigma in many binary and ternary systems.[1] The crystal structure of the sigma phase is still unknown, though a tetragonal unit cell was tentatively suggested as a first approximation[1, 3] to describe it. Existing evidence was held to indicate that the occurrence of the sigma phase in binary alloy systems is confined to transition metals having a body-centred or face-centred cubic structure. It also appears that sigma exists only in systems for which the two following conditions are satisfied:—The atomic diameters of the two metals do not differ by more than 8 per cent, and one of the metals has a body-centred cubic structure, while the other is face centred at least in one of its allotropic forms. Examples are Cr-Fe, Cr-Co, V-Fe, V-Co, &c.[1]

The work of Dulis and Smith[2] was largely devoted to the establishment of a micrographical technique for the identification of the sigma phase and for its differentiation from ferrite and carbide in austenitic steels. A number of etching reagents and procedures have already been suggested for the identification of sigma, but another is now added, viz., repeated polishing and etching with (1) picric and hydrochloric acids in alchohol to reveal all the constituents present, (2) alkaline ferricyanide at room temperature to stain carbide leaving ferrite and sigma unattacked, and (3) chromic acid (electrolytically) to attack carbide and sigma. By elimination sigma is thus identified. The method is not applicable to steels containing titanium or niobium as the alkaline ferricyanide does not attack the carbides of these metals.

Formation and Re-solution.—By microscopical examination, supplemented by X-ray and magnetic permeability tests, the mode of formation and re-solution of sigma were explored in a fully austenitic 18:8 Cr-Ni-Mo steel.[3] At 815 deg. Cent. carbide precipitation preceded sigma formation, and was complete in a relatively short time, while precipitation of sigma was incomplete after 3000 hours. Both carbide and sigma formed in the grain boundaries, decreasing the ductility of the steel, at least at room temperature. On reversing the process at 1093 deg. Cent., ferrite was formed as an intermediate product in the process of re-solution of the sigma in austenite.

The conditions of formation of sigma in 25:20 chromium-nickel steel (with carbon 0·08, manganese 1·2–1·8, and silicon 0·5–0·8 per cent) were dealt with by G. N. Emmanuel.[3] Mechanical tests, metallographic examination and X-ray diffraction were used as means of tracing the formation and evaluating the effects of the sigma phase. When the alloy was held for prolonged periods at temperatures 593 deg. to 871 deg. Cent., the sigma phase formed directly from the austenitic matrix. The phase formed more rapidly, and over a wider range of temperature (538 deg. to 871 deg. Cent.) in the cold-worked than in the annealed condition. The rate of sigma precipitation increased with temperature, reaching a maximum at 815 deg. Cent. and decreasing to zero at 926 deg. Cent. Sigma formed less readily in an initially coarse-grain material, since it tends to nulceate in the grain boundaries and any diminution in grain-boundary area reduces the amount of precipitation.

Effect of Mechanical Properties.—The effect on mechanical properties was also studied by Emmanuel.[3] Notched-bar impact tests gave the most sensitive indication of the presence of sigma. Room temperature impact values were at a minimum in specimens exposed at 780 deg. to 871 deg. Cent. The room temperature toughness of the most severely embrittled specimens was restored by heating them at 1022 deg. Cent. for two hours and quenching in water. The sigma-containing material was not brittle at elevated temperatures, and prolonged heating at 980 deg. to 1090 deg. Cent. indicated that no appreciable grain growth took place in these 25:20 chromium-nickel steels below 980 deg. Cent.

By using cold work and prolonged heating periods at 482 deg., 565 deg. and 649 deg. Cent. J. J. Heger[4] found that the sigma phase was formed in commercial 17 per cent chromium steel, showing that the sigma-alpha boundary for this material was at a lower chromium content than existing diagrams would indicate. At 482 deg. Cent. the sigma phase was precipitated in particles too finely dispersed to be identified microscopically. Cast chromium-nickel steels were the subject of two papers.[5, 11] Malcolm and Low[6] investigated cast 18:10 and 16:35 chromium-nickel steels, alone and with additions of molybdenum, niobium, vanadium or tungsten. The existence of sigma after long exposure at temperatures between 540 deg. and 815 deg. Cent. was determined by room temperature impact tests, confirmed by X-ray analysis and microscopical examination. It was clearly established that the embrittling phase present in the 18:10 steels was sigma, but this constituent could not be conclusively identified in the 16:35 steels. The embrittling effect of sigma on the cast austenitic steels was evident in tests at elevated temperatures, but was pronounced at room temperature, though the impact value of these steels was not unduly low compared

with those of low-alloy ferritic materials.

Improvement of Creep Strength.—The advantageous utilisation of sigma precipitation was referred to by W. O. Binder,[5] who investigated steel with chromium 18 to 20, nickel 8 to 12 per cent and similar steels containing niobium. The temperature range most favourable to the formation of sigma was 600 deg. to 800 deg. Cent. Precipitation was increased by straining at elevated temperatures. Cold working, followed by low-temperature annealing, accelerated the formation and growth of sigma particles, whereas high-temperature annealing rendered the reaction more sluggish and inhibited growth. The niobium-bearing steels did not form a large amount of sigma, owing, it was suggested, to the propensity of niobium to form phases other than ferrite. In the 18 : 10 chromium-nickel steel containing ten times as much niobium as carbon, the precipitation of sigma in a critical particle size was held to have a beneficial effect on creep strength. The optimum temperature of treatment for strengthening this type of steel by controlled sigma formation was found to be about 600 deg. Cent., and this strengthening was obtained, in the steels studied, without deleterious effect on the other properties.

Later Work

The study of the sigma phases is proving to be a very complicated matter and with the use of more complex alloys containing molybdenum and tungsten, other binary intermetallic compounds—the xi phases—and possibly ternary phases also enter into the constitutional diagrams. An understanding of the constitution of these alloys has advanced considerably as a result of the work of H. J. Goldschmidt and others. This matter was specially referred to in a recent paper by G. T. Harris and H. C. Child, and in other papers presented at the Symposium on "High-Temperature Steels and Alloys for Gas Turbines."

The mechanical effect of sigma and the effect of alloying elements on sigma formation have received attention in two later papers published in America. When methods of accelerating sigma formation are applied, instances are reported of identification of the phase in alloys previously regarded as immune. The commercial 17 per cent chromium steel mentioned above is a case in point.[4] Another example is given by A. E. Bindari, P. K. Koh and O. Zmeskal.[12] They found that, in a steel containing approximately carbon 0·1, chromium 19, nickel 9, tungsten 1, molybdenum 0·3, niobium 0·3 and titanium 0·2 per cent, sigma formed at sites occupied by ferrite in the duplex austenite-ferrite structure. Formation was very slow in the annealed steel, but was much accelerated by strain hardening. It seemed likely from other results that with a lower percentage of molybdenum the rate of formation of sigma would have been slowed down tremendously, giving the impression that this type of steel was immune. In a paper by J. J. Gilman[13] the hardening of high-chromium, ferrite-austenite steels by sigma formation was discussed. The steels investigated contained 25 per cent of chromium with enough manganese or nickel to render them partially austenitic, and silicon, molybdenum and manganese to promote the formation of the sigma phase. The steels were hardened to a Vickers Diamond Hardness of 370–450 by the formation of sigma and retained their hardness at elevated temperatures for an indefinite period. They showed no indication of softening after as long as 1000 hours at 760 deg. Cent. The hardness is of the mixed phase type and depends on the amount and distribution of the phases. In 25 : 4 : 5 chromium-nickel-manganese steel, after 500 hours at 760 deg. Cent., the macro-hardness (470 V.D.H.) is the resultant of the hardness of the austenite phase (220 V.D.H.) and of the sigma phase (875 V.D.H.). Alloy elements were found to affect the rate of formation of sigma, and consequently the rate of hardening, in the following ways :—increase in chromium is most effective ; molybdenum or silicon, very effective ; manganese, effective ; cobalt, slightly effective ; while carbon and nitrogen decrease the rate and the action of nickel depends on the balance of composition. The greater the amount of ferrite in the initial structure the greater the rate of sigma formation. The effect of other elements was also investigated in a less extensive way. Vanadium, tungsten, aluminium and phosphorus seemed to increase the rate of formation of sigma, while boron appeared to decrease it slightly. Gilman found, in common with other investigators, that cold working and low rolling temperatures increased the rate of formation of sigma, whilst annealing the steel at increasing temperatures from 925 deg. to 1150 deg. Cent. had the opposite effect. He also found that sigma forms much less rapidly in cast than in wrought materials ; the rate depends apparently on the rate of cooling during solidification. The sigma-hardened, high-chromium steels are not free from the sigma-phase embrittlement which has caused metallurgists to look upon sigma as a constituent to be avoided whenever possible ; but in the high-chromium steels this disadvantage is counterbalanced by the excellent hot-hardness of the sigma-hardened material, which has given good service as internal combustion engine exhaust valves.

In published papers there is still a considerable conflict of opinion, both as to the possibility of making advantageous use of the sigma phase in creep-resisting steels for high-temperature service, and as to the extent and seriousness in practice (owing to sluggish nature of the reactions involved) of its unwelcome appearance in the molybdenum-bearing, austenitic, corrosion-resisting steels.

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[2] E. J. Dulis and G. V. Smith, "Identification of Sigma by Etching, Magnetic and X-Ray Methods."

[3] G. N. Emmanuel, "Sigma Phase and Other Effects of Prolonged Heating at Elevated Temperatures on 25 Per Cent Chromium, 20 Per Cent Nickel Steel."

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[12] A. E. Bindari, P. K. Koh and O. Zmeskal, "Sigma-Phase Formation in a Wrought Heat-Resisting Steel," American Society for Metals, October, 1950, Preprint No. 13.

[13] J. J. Gilman, "Hardening of High-Chromium Steels by Sigma-Phase Formation," American Society for Metals, October, 1950, Preprint No. 11.

High-Temperature Micro-Hardness Tests

An apparatus has been devised at the U.S. National Bureau of Standards for measuring the hardness of metals at temperatures up to 900 deg. Cent. in an inert atmosphere. The main parts of the apparatus are (1) the indenting mechanism, consisting of a Vickers' diamond mounted on a shaft of fused silica, (2) a mechanical device for raising or lowering the indenter, (3) a micrometer device for orienting the specimen under the indenter, and (4) the heating unit in which the specimen is held for fifteen minutes at constant temperature before a test is made. The force on the indenter may be varied either by deadweight loading or by changing the gas pressure in the apparatus. The apparatus was specially devised for testing thin electrodeposits ; and, with loads as low as 200 grammes, deposits down to 0·003in in thickness may be tested. Some typical measurements are given in Figs. 1 and 2. Electrodeposited chromium and nickel were permanently softened by heating ; when cooled again to room temperature their hardness is lower than initially. In contrast, cobalt and cobalt-tungsten alloys regain a large part of their initial hardness or even exceed it, provided that the maximum temperature to which they have been exposed is not excessive.

The hardness of bars of molybdenum and of

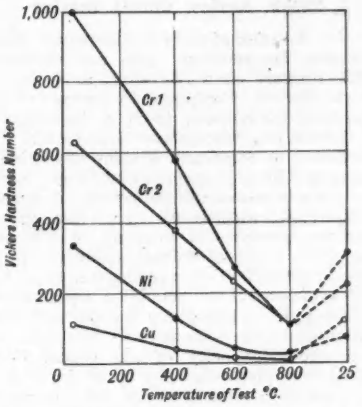


Fig. 1.—*Hot-Hardness of Commercial Copper Bar and of Electrodeposits of Bright Chromium* (1), *"Soft" Chromium* (2) *and of Nickel (Brenner).* *

copper reverted to the original values after cooling. The hardness of molybdenum at various temperatures was found to be very reproducible, and check tests on this metal

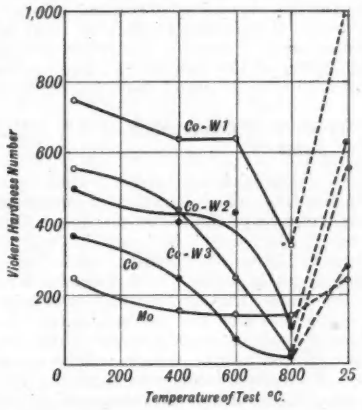


Fig. 2.—*Hot-Hardness of Commercial Molybdenum Bar and of Electrodeposits of Cobalt-Tungsten Alloys with* (1) 31 *per cent,* (2) 15 *per cent, and* (3) 8 *per cent Tungsten, and of Cobalt (Brenner).*

were used to see that the apparatus was functioning properly. Maintenance or increase of hardness after heat-treatment cannot, of course, be taken as evidence of good hot-hardness.

Cracks in Alloy Case-Hardening Steels

Radial cracks, found in the case of deeply carburised alloy steel bars on cooling after cementation or on normalising, are due to stresses which arise because the expansion which accompanies the transformation of the core occurs after the case has fully transformed to martensite. The occurrence of such cracking in alloy case-hardening steel has been studied by F. Brühl and H. J. Wiester,† who found that the cracking only occurs over a limited range of cooling rates, usually including air cooling. Low-nickel, nickel-chromium steel and nickel-free chromium steels were more subject to this form of cracking than steels with 4 per cent of nickel. Cracking was avoided if cooling was interrupted in the temperature region of pearlite formation so that full transformation of case and core was produced, or, without sacrifice of hardness, if the rate of cooling was accelerated by oil-quenching so that the case was transformed only after the transformation of the core, transformation in the case being delayed by its higher carbon content. By this means the expansion occurring during martensite formation in the case tends to relieve the stresses set up by the transformation of the core.

*A. Brenner : U.S. National Bureau of Standards, *Journal of Research*, Vol. 46, page 126.

†*Archiv für das Eisenhüttenwesen*, 1950, Vol. 21, page 159.

American Engineering News

(From our American Correspondent)

A 220kV Airblast Circuit Breaker

A series of tests at the power station of Grand Coulee Dam have proved that a 220kV airblast circuit breaker, made by the Brown Boveri Company of Switzerland, is capable of interrupting in 2½ cycles faults up to 11,000MVA, three-phase equivalent. This is believed to constitute a value never before approached by airblast circuit breakers. Earlier tests demonstrated the ability of the breaker to interrupt, without restrike, charging currents for transmission lines up to 300 miles long. The unit, which was submitted to the tests, is rated for interrupting duties of 6000 MVA symmetrical and 9000MVA asymmetrical. Several of the single-phase line-to-earth interruption tests were made with the maximum short circuit capacity of the Grand Coulee Dam power plant and the North-West power pool, which constitutes one of the largest concentrations of power in the world. In each case the breaker interrupted within 2½ cycles after trip-coil energisation without any visible distress. Examination of one of the eight sets of fixed and movable contacts per pole immediately following the tests disclosed signs of severe arcing. However, there was no damage which would immediately interfere with further successful operation. Following the tests, the circuit breaker is now being installed at the Columbia substation in central Washington of the Bonneville Power Administration to provide actual operating experience.

Progress of Construction of S.S. "United States"

Details have been released by the U.S. Maritime Administration of the progress of construction of the 48,000-ton liner "United States." The vessel is being built by the Newport News Shipbuilding and Drydock Company at Newport News, Virginia, for the United States Lines. Her keel was laid on February 8, 1950, and she is expected to be launched early in the summer of this year. It is expected that the vessel will be ready to enter the trans-Atlantic service of the United States Lines during the summer of 1952. While a serious delay was caused by the Government decision announced last September, and later rescinded, to take over the vessel as a transport, the yard is making every effort to maintain the planned rate of progress of construction. Approximately 90 per cent of the hull work has been completed up to the promenade deck and work is already in progress on the sun and sports decks. The two funnels will be emplaced prior to launching. The boilers have been installed, the shafting is in place and many of the auxiliary power units have been fitted. The turbines and the main reduction gears are now being tested.

A Third Tube for the Lincoln Tunnel

The Port of New York Authority has announced plans for the construction of a third tube for the Lincoln Tunnel crossing the Hudson River between mid-town Manhattan and Weehawken, New Jersey. Construction costs have been estimated at 85,000,000 dollars and completion of the tube may be expected in 1957. The new crossing is to be constructed about 150ft south of the existing tubes and will provide for 8,500,000 more vehicles a year able to pass through the Lincoln Tunnel. Thus, it will increase the annual volume by 50 per cent and will double the peak-hour capacity. The proposed third tube will carry Manhattan-bound traffic and the existing northern bore will handle vehicles bound for New Jersey, as at present. The middle (now the south) tube will become a reversible artery: eastbound in the morning and westbound in the evening. The new tube will be 7944ft in length from portal to portal, 31ft in diameter and will dip 97ft below mean high water. On the New Jersey side it is intended to widen the tunnel plaza from 182ft to 254ft and to add five additional toll booths to the present thirteen. It has been estimated that the new tube will require approximately 45,000 tons of cast iron tunnel lining, 900 tons of structural steel, 4500 tons of reinforcing steel, 4500 tons of cast iron castings and pipe, 1700 tons of cast steel tunnel lining and 1600 tons of steel bolts.

Continental Engineering News

(From our Continental Correspondent)

Bridge Reconstruction in Germany

Bridge reconstruction work started soon after the end of the war and since that time many bridges have been rebuilt, including the famous Cologne–Deutz bridge, a plate girder structure, 1435ft long, having a particularly pleasant appearance. Reconstruction work recently completed includes two highway bridges—the Krefeld bridge over the Rhine, and the Neustadt bridge over the Wiedbach. The Krefeld bridge is a suspension bridge 2800ft long with a central span of 820ft. Its construction required the use of 7600 tons of steel. The decking is 63ft wide. The Neustadt bridge, on the motor route Cologne–Frankfort, crosses the valley of Wiedbach at a height of 180ft. It consists of five lattice girder spans. The overall length is about 1000ft.

Bus Garage at Vienna, Austria

A large garage to shelter 100 buses has recently been erected at Vienna. The garage is covered with a shell roof, measuring 270ft by 280ft. The concrete shell, the thickness of which varies from 3in (centre) to 6in (sides), is covered with a layer of cellular concrete for insulation purposes. It is supported on five trusses resting on the end walls and three central columns. To facilitate movement inside the hall, the number of supports has been reduced to a minimum. The street frontages are provided with six doors of which the two main doors are 43ft wide. There are also two small halls measuring 210ft by 53ft, covered by eight transverse barrel shells. The Vienna bus garage was built by the contracting firm Ed. Ast and Co.; Professor A. Pucher being the consulting engineer to the contractors.

Reconstruction of the Val Benoit Bridge at Liege, Belgium

Belgian National Railways are now erecting the Val Benoit Bridge over the River Meuse at Liége. Before the war the Meuse was crossed at Val Benoit (Liége) by a 675ft steel structure composed of three Vierendeel truss spans. It was destroyed at the outbreak of the war in September, 1939. This structure was replaced during the war by a single-track bridge, composed of a central Vierendeel truss span, 279ft long, and side spans of plate girder construction. It was heavily damaged by air bombing, but was partly restored by American Army engineers.

The new Val Benoit Bridge, designed by Professor R. Desprets, is a plate girder structure of pleasant appearance. It consists of three central continuous spans, each 176ft long, and two side spans each 82ft long. The main girders are generally 12ft deep. The contract, which required the use of 2000 tons of steel, was let to the Ateliers Métallurgiques de Nivelles.

A Long-Distance Power Transmission Line in Austria

Austrian hydro-electric resources are situated mainly in the western part of the country, while industrial plants are largely concentrated in the east. Power production, therefore, means long-distance transmission lines. The first 110kV line was built in 1922–23 to bring electric energy from the Opponitz and Gaming power plants to the Vienna area, a distance of about 75 miles. A 220kV line crossing of the Danube was built later between Ernsthofen and Bisamberg. Another line, 130 miles long, linking Kaprun with Ernsthofen, and crossing the Wagrain Valley, is being built at present. Completion is expected this year.

French Engineering News

(From our French Correspondent)

Considerable work is now being carried out at the port of Lille, and the Ponts-et-Chaussées administration is constructing a canal which will take 1350-ton barges. Parallel with this work, the Lille Chamber of Commerce is increasing warehousing facilities and has demolished the port's fortifications in order to construct 4½km of quays, the new port area covering over 80 hectares.

Since the end of 1948 a 40,000 cubic metre warehouse, served by six travelling cranes of 6½ tons and 2½ tons, has been in use, together with a 7000 hectolitre wine storage vat, with appropriate pumping and filtering plant. It is planned to increase the wine storage capacity to 10,000 hectolitres and to provide covered and open storage space for coal, sand and gravel. A cotton warehouse is at present under construction, having an area of 3000 square metres, and a third warehouse covering 18,000 square metres is now nearing completion. Considerable installation of cranes and handling equipment is also planned or in progress.

The second part of the port can now receive 1350-ton barges. There are three 45m wide wet docks, including one, 350m long, for construction materials, a second, 250m long, for coal, and a third, 170m long, to receive barges carrying other cargoes.

* * *

In reply to a recent question, the Minister for Industry stated that the Rance sea power project continued to be studied throughout 1950. Amongst other investigations, a number of preliminary surveys were continued, including soundings of the river bed and soil mechanics surveys. The work has now advanced sufficiently to enable Electricité de France to prepare a detailed lay-out of the proposed scheme based on a low-head power station. The most awkward technical difficulties concerning the civil engineering work have been clearly indicated by the preliminary tests, so that it has been possible to estimate an approximate cost per kilowatt-hour. This would appear to be about 20 per cent higher than the average price per kilowatt-hour in corresponding hydro-electric plants. The total cost of the project would be about 40 milliard francs, and the annual production is estimated at 800 million kilowatt-hours. Owing to lack of credits, however, it is not possible for the French authorities to contemplate starting work on it at the present time.

* * *

The French Government has reduced credits for engineering developments in rural areas by 40 per cent. This statement caused surprise in the National Assembly, and the Minister of Economic Affairs pointed out that the 1950 credits had not been completely used. He said that last year some 30,000km of electric cable had been laid to meet rural needs, and that piped water had been brought to 350,000 rural homes. He insisted that an increase in credits would not solve the problem of rural development.

* * *

Some 10,500 firms are exhibiting at this year's Paris Fair. The mechanical and engineering section is an important one, in spite of the decision of the machine tool manufacturers to hold a separate exhibition later in the year. The general impression is that this year's prices show a considerable increase over those prevailing at the time of the 1950 Fair.

* * *

The French Railways have announced a deficit for last year of 87 milliard francs (about £87 million). Of a total expenditure of 382 milliard francs, 66 milliards only were spent on upkeep and engineering works. Nevertheless, over the past ten years, it is pointed out, improvements in the service of the railway have continued. The main cause of the deficit is attributed to redundant personnel; the forty-hour week is blamed in particular, which, it is said, has forced the railways to engage extra workers at an estimated cost of about 35 milliard francs.

Industrial and Labour Notes

British Overseas Trade

Exports of United Kingdom goods during March were valued at £190,500,000, compared with an average of £194,900,000 for the months of January and February. If allowance is made for the Easter holidays, by adjusting the figures to a standard working month of twenty-six working days, the rate of exports in March was about equal to the average for January and February. In the first quarter of this year, the value of exports amounted to £580,300,000, which was 7 per cent above the average for the whole of 1950, but 4 per cent below the fourth quarter of last year.

The Board of Trade says that the value of exports of manufactured goods in the first quarter of this year, at £506,500,000, was 8 per cent above the 1950 average, but that exports of raw materials, valued at £23,900,000, were 9 per cent below last year's average, coal exports being reduced by more than a half. Among manufactured goods, exports of vehicles, including locomotives, ships and aircraft, in the first quarter of this year, were 4 per cent above last year's average. There were 27,590 new cars and chassis exported in March, which brought the quarter's total to 88,821, a figure 11 per cent below the 1950 average. The number of commercial vehicles and chassis exported in the first quarter was 6 per cent less than last year's average, the March figure being 10,040, but the number of agricultural tractors exported last quarter was, at 26,724, 27 per cent above the 1950 average. Machinery exports during the first quarter of this year were valued at £78,900,000, a figure slightly below the 1950 average, and iron and steel exports were 10 per cent below last year's average.

The value of imports in March was £303,400,000, which brought the total for the first quarter of the year to £848,200,000, an increase of 30 per cent on last year's quarterly average. The outstanding increases, of course, were in raw materials, the quarter's total value for this class being £387,900,000, which was 56 per cent above last year's average.

Productivity in the Steel Industry

In the latest number of its *Monthly Statistical Bulletin*, the British Iron and Steel Federation shows that, by the end of last year output per man-year in steel melting and rolling in this country had reached a level 39 per cent above 1938, and nearly 20 per cent higher than in 1937, which was the best pre-war year. Since the war there has been a substantial improvement each year, except in 1947, when the dislocation of production owing to the fuel crisis wiped out the gain that might otherwise have been expected.

Post-war gains in efficiency in the British steel industry have been helped, of course, by the continuous working week which has cut down interruptions of plant operation. Other contributory factors are the extension of oil firing, which speeds up the melting process and, therefore, the number of charges which can be obtained per week, and progressive improvements in the handling of materials. The gains in ingot steel output have been reflected correspondingly in the rolling operations. Moreover, progress with the steel development plan has been continually of assistance in improving productivity, although the major contribution which is expected from the larger schemes under the plan has yet to be realised.

The Federation again points out, however, that in the immediate future there may be temporary difficulties in increasing productivity in the steel industry. The tightness of raw material supplies increases the risk of plants operating on a hand-to-mouth basis, and without the continuity of production which greatly facilitates efficient operation. The diversion of shipping for the import of coal and other abnormal traffics has meant a serious loss of iron ore imports at a time when the world iron ore situation is, in any event, difficult. Similar repercussions are being felt in the shipping of imported scrap and pig iron from the Continent, the vessels normally engaged in this traffic being employed in trans-shipping American coal at Rotterdam for delivery in smaller vessels to a variety of British ports. Supplies of raw materials this year, the Federation says, are unlikely to be sufficient for the production of more than about 16,250,000 tons of steel, and if there is continued serious interference with shipping, or other essentials for maintaining output, production may fall below that level. It is, however, envisaged that by about 1955 raw material supplies will be expanded sufficiently to permit a steel production of 18,000,000 tons.

Education for Management

Under arrangements made by the Anglo-American Council on Productivity, a team which is to study education for management left for the U.S.A. on Tuesday last. The sending of the team implements the recommendation made in 1947 by a committee which advised the Minister of Education on the educational facilities desirable for management in industry and commerce. That committee suggested that a small, but authoritative, commission should be appointed to examine and report on existing facilities for management education in the U.S.A., it being asserted that the U.S.A. had "a wealth of equipment, of experience and of trained personnel in this field to which there is no parallel in Great Britain."

The team is under the leadership of Lieut.-Colonel L. Urwick, chairman of the British Institute of Management, and its aims are to estimate the volume of effort devoted to education in management subjects in the U.S.A. at all levels; to visit selected educational establishments providing schemes of education and training for management, and to study their methods; to attempt to assess the acceptability of such education in management subjects to industry and commerce, and its influence on the subsequent careers of students, and to report upon the methods and success of formal training schemes within industry itself. In order to make the best use of its tour of six weeks, the team will be divided into five groups, each of which will possess both educational and industrial backgrounds. It is hoped that four of these groups may be able to spend from ten to twelve days with each of three different kinds of educational institutions in the U.S.A., and that the fifth group will concern itself with discovering the volume of effort devoted to formal education in management subjects, and will co-ordinate the work of the other groups.

Foremanship Training in Technical Colleges

A special committee set up by the British Institute of Management has recently surveyed the facilities which exist for the training of foremen. It has now produced a report entitled "Foremanship Training in Technical Colleges," which has been published by the Institute, price 2s. 6d.

Although it does not cover the whole field, the report indicates the deficiencies which are to be found at present in training for foremanship, and it suggests some practical ways in which technical colleges can give immediate help. The recommendations, it is claimed, are based on comprehensive evidence of the needs of industry and a study of current methods of meeting them. In all its deliberations, the committee kept very much in mind the problems of the smaller firms which, for such matters as the training of foremen, are entirely dependent on external courses.

The report suggests that, in addition to the existing facilities for foremanship training in technical colleges, there is a need for recurrent, short courses of a non-examinational character; that these proposed short courses might consist of six meetings held either weekly or, if necessary, at fortnightly intervals, and that progress and attendance reports should not normally be submitted to employers or others similarly interested, but that evidence of completion of a course should be available to those who have taken part. It is then recommended that the following aspects of foremanship might be dealt with in a series of five such courses:—The foreman and industry; the foreman and his responsibilities; the foreman and human relationships; aids to foremanship, and the foreman and communications.

In a foreword to the report, Sir Charles Renold emphasises that the short-term programmes suggested are designed to appeal to the established foreman, adding that such brief courses may be an essential introduction to, but are no substitute for, progressive long-term training within industry and outside. Sir Charles considers that training for the potential foreman, and the contribution of the technical colleges to the long-term training arrangements of the smaller firms, are two particular aspects of the problem which deserve further and urgent study.

Management Scholarships in the U.S.A.

The Ministry of Education has announced that forty scholarships for the study of management in the U.S.A. are to be awarded in 1951. These are in addition to the thirty-five scholarships for the study of technology recently announced. Funds for these awards are to be provided by the American Economic Co-operation Administration, and the scheme is sponsored by the Ministry of Education, the Scottish Education Department and the British Institute of Management. The aim of the scheme is to enable suitable candidates to extend their knowledge and experience of management by spending nine months in America, undergoing a period of organised study together with plant experience. Successful candidates will normally spend approximately six months taking a special course of management subjects and techniques at selected universities or technological institutes, together with periods in industrial plants, and in visits to professional, Government and labour organisations.

The awards will be open to persons between the ages of twenty-three and thirty-five, of adequate educational standard and with at least three years' industrial experience, who expect to occupy positions of responsibility in industry, or who propose to teach management subjects. Provision will be made for the tuition fees, books and travelling expenses in the U.S.A. and for suitable maintenance allowances. The cost of the return passage to the U.S.A. will be met from public funds. Successful candidates will be expected to leave for the U.S.A. early in September, 1951, and applications must reach the Ministry of Education by May 15th. Full details of the scheme may be obtained from the Ministry of Education, Curzon Street, London, W.1, or from the British Institute of Management, Management House, 8, Hill Street, London, W.1.

An Industrial Safety Exhibition

The Birmingham and District Industrial Safety Group is organising an exhibition, which will be held in the Bingley Hall, Birmingham, from May 30th to June 2nd. There are to be over fifty stands, occupied by firms manufacturing industrial safety and welfare equipment, including all kinds of machine guards, fire-fighting appliances, protective clothing and goggles.

The firms constituting the Birmingham and District Group will be demonstrating ideas which they have developed and used in their own factories and films dealing with safety, welfare and hygiene topics will be shown on each day of the exhibition. Arrangements are being made for workers, supervisors and managers of all grades to visit the exhibition. Invitations have also been sent to the students of secondary schools and technical colleges in the area.

Notes and Memoranda

Air and Water

RETIREMENT OF MR. S. G. WEST.—The Union-Castle Line has announced the retirement of Mr. S. G. West, its naval architect. He has been with the Union-Castle Line for forty-five years and was appointed naval architect in 1927. Mr. West's successor is Mr. J. A. H. Lees, who has been his assistant for the last five years.

ADMIRALTY CHARTS.—Due to the increases in cost of materials the Admiralty announces that from April 23, 1951, the charges for Admiralty charts, hitherto available at pre-war prices, are increased by 33⅓ per cent. The Admiralty Notice to Mariners service will continue to be available as before, so that users can keep their charts up to date. The notices, which are published in weekly and quarterly editions are available for consultation at a number of ports. The 1951 edition of the Catalogue of Admiralty Charts will be available shortly at a price of 2s.

THAMES EFFLUENTS.—The Minister of Local Government and Planning has appointed a departmental committee with the following terms of reference :—"To consider the effects of heated and other effluents and discharges on the condition of the tidal reaches of the River Thames, both as at present and as regards any proposed new developments in the area, and to report." Professor A. J Sutton Pippard, M.I.C.E., head of the Civil Engineering Department at the Imperial College of Science and Technology, is chairman of the committee. The secretary is Mr. A. R. Isserlis, and all communications should be addressed to him at the Ministry of Local Government and Planning, Whitehall, S.W.1.

TAXATION AND THE SHIPPING INDUSTRY.—At a recent council meeting of the Chamber of Shipping of the United Kingdom, Lord Runciman, vice-president, said that the suspension of the initial depreciation allowance announced by the Chancellor of the Exchequer in his Budget statement was of serious and direct concern to the shipping industry. Members of Parliament had been left in no doubt as the the effect of the proposal on the industry's shipbuilding programme, and the need for the fullest consultation in the industry. A statement had been forthcoming from the Chancellor of the Exchequer that he appreciated there was a special case for consideration in relation to new ships, the building of which had already begun, and where expenditure would not be completed by April, 1952. The suspension of the initial allowance to shipping would disturb, and indeed prevent, the completion of the building programme of the British Mercantile Marine, as urged by the Government itself. Shipping, Lord Runciman asserted, was just as much part of the defence programme of the Government as capital expenditure on re-armament was to the armed forces.

Miscellanea

LONDON'S TECHNICAL COLLEGES.—The L.C.C. Education Committee has recommended to the Minister of Education that the following projects in the London Scheme of Further Education should be included in the 1952–53 programme :—Extensions at Chelsea Polytechnic, Norwood Technical College, and Wandsworth Technical College, and the provision of a new technical college at Blackheath.

CARRIAGE BOGIE STABILISER UNITS.—In the article on the carriage bogie stabiliser units developed by the Andre Rubber Company, Ltd., which appeared in our issue of April 13th, we omitted to mention that these units were first taken up by the Birmingham Carriage and Waggon Company. That company built the bogies of the five-coach sets for Egypt, which were supplied by the English Electric Company, Ltd., and on which the stabiliser units described were fitted.

"FRACTURE UNDER COMBINED STRESS CREEP CONDITIONS OF A 0·5 PER CENT MO STEEL."—In the bibliography to the article by A. E. Johnson and N. E. Frost under this title in our issue of April 6th, there is a reference to a paper entitled "The Properties and Mode of Rupture of a Molybdenum and a Molybdenum-Vanadium Steel, Judged from Prolonged Creep Tests to Fracture," by H. J. Tapsell, C. A. Bristow and C. H. M. Jenkins, "Proceedings," Inst. Mech. Eng., Vol. 146 (1941), page 208. The Electrical Research Association asks us to point out that the paper thus referred to is, in fact, E.R.A. Report Ref. J/T 128. A reference to this same source was made in an article in our following issue entitled "Microscopical Examination of Creep Specimens," by E. A. Jenkinson, an article that formed an appendix to the one by Johnson and Frost.

RADIOACTIVE ISOTOPES IN INDUSTRY.—A conference on "The Use of Radioactive Isotopes in Industry," which has been arranged by the Industrial Research Committee of the Federation of British Industries and the Atomic Energy Research Establishment, will be held at the Institution of Electrical Engineers, Savoy Place, London, W.C.2, on Tuesday next, May 1st. It will begin at 10 a.m. and conclude at 4 p.m. Sir Wallace Akers, chairman of the F.B.I. Industrial Research Committee, will preside, and a general introduction to the theme of the conference will be given by Sir John Cockcroft, F.R.S., Director of the Atomic Energy Research Establishment.

PRESENTATION LUNCHEON TO MR. J. C. J. PHILLIPS, — Members and guests of the Accessory and Component Manufacturers' Section Committee of the Society of Motor Manufacturers and Traders met at the Hyde Park Hotel on April 10th at a luncheon held to pay tribute and make a presentation to Mr. J. C. J. Phillips, M.B.E., who retired from the staff of the Society last year after forty-four years' service. Following the luncheon, Mr. W. Shelley, a past chairman of the section committee, proposed a toast to Mr. Phillips, and Mr. E. J. Scott, M.C., chairman of the committee, who presided at the function, gave an admirable account of Mr. Phillips's work on exhibitions organised for the motor industry. After the luncheon Mr. Phillips was presented with a gold wrist watch, suitably inscribed, and a substantial cheque.

OBITUARY.—We have learned with regret of the death, which occurred recently, of Mr. H. Osbourne Bennie, a director of Scottish Machine Tool Corporation, Ltd., Glasgow, until his retirement just over a year ago. He was eighty-six. Mr. Bennie took over control of the machine tool business of James Bennie and Co., Polmadie, at the early age of twenty-one. The successor to that firm was acquired by the Scottish Machine Tool Corporation in 1937, Mr. Bennie being appointed to the board. A year later he became managing director of the Corporation, in which office he continued until 1944. . . . We record, also, with regret, the death, on April 12th, of Mr. T. G. Frost, London sales manager of Chamberlain and Hookham, Ltd. Mr. Frost was sixty-one and had been actively associated with the electric meter industry throughout his business career. He joined Chamberlain and Hookham, Ltd., in 1908.

"THE ELLIOTT JOURNAL."—We welcome the first issue of a new publication entitled "The Elliott Journal." Its aim is to acquaint industry with developments in the arts of measurement and instrumentation emanating from Elliott Brothers (London), Ltd., Century Works, Lewisham, London, S.E.13. In a Foreword to the opening number of this journal, Sir Ben Lockspeiser refers to the contribution made by the Elliott organisation to measurements and instrument making during the past 150 years, a subject which is elaborated in a subsequent article in the same issue. Other articles deal with magnetic amplifiers and their industrial application, pulsed circuits for resistance strain gauges, a photoelectric curve follower and an application of the force-balance principle to pneumatic instruments for process control. It is proposed to publish "The Elliott Journal" half-yearly, and we learn that copies are obtainable on application to the company at the address given above.

CENTRAL INDEX OF TRANSLATIONS.—In order to assist industrialists and scientific research workers to keep themselves informed of developments in research in foreign countries, the Association of Special Libraries and Information Bureaux is preparing a central index of translations. The index will include scientific papers, reports and published articles which appear in foreign journals. Work on the index has already begun, and it is intended that it shall provide a guide to all translations held in this country and the Commonwealth. The usefulness of the index will depend on its comprehensiveness, and to make this as wide as possible the co-operation of organisations at present in possession of translations is sought. All organisations holding translations and willing to take part in the scheme are invited to get in touch with ASLIB. A limited number of translations has already been indexed and inquiries concerning the existence or location of translations are being dealt with. Inquiries can be made by telephone, letter or personal call. The name of the author or of the journal in which the paper sought for appeared should be quoted. There is no charge for the use of the index service. All inquiries, and all offers of co-operation in preparing the index, should be made to ASLIB, 4, Palace Gate, London, W.8 (Telephone, WEStern 6321).

WORLD METALLURGICAL CONGRESS.—The Economic Co-operation Administration has decided to sponsor a mission—consisting of experts from countries in the Organisation for European Economic Co-operation—to the World Metallurgical Congress. The Congress, which is being organised by the American Society for Metals, is to be held in the U.S.A. next September. Among the subjects which it will discuss are steel-making and refining, preparation of metals, research in metals, marketing and fabrication and machining of metals. As well as attending the Congress, the members of the mission will have an opportunity to visit several American factories and research institutions. Information about membership of the O.E.E.C. mission can be obtained in this country from the British Engineers' Association, 32, Victoria Street, London, S.W.1.

EDMUND MILLS HARWOOD MEMORIAL SCHOLARSHIP.—The governing body of the University of Manchester announces the offer of a scholarship tenable in one of the University courses in the departments of Mechanical Engineering, Electrical Engineering or Municipal Engineering in the College of Technology, Manchester. The scholarship has been founded by Mrs. R. M. Harwood, in memory of her husband, Edmund Mills Harwood, a former student at the College. Students intending to proceed to the ordinary degree of B.Sc.Tech. must have satisfied the requirements for entry upon a degree course in accordance with the regulations of the Joint Matriculation Board of the Northern Universities. For admission to a higher course leading to the degree of B.Sc.Tech. with Honours, a pass in at least three approved subjects at the advanced level of the examination for the General Certificate of Education is also required. Forms of application and further information may be obtained from the Registrar, College of Technology, Manchester, 1.

Personal and Business

THE STEEL COMPANY OF WALES, Ltd., states that Mr. Idris Williams has been appointed assistant to the plant manager at the Trostre works.

THE BRITISH BROADCASTING CORPORATION has appointed Mr. L. W. Turner, A.M.I.E.E., as assistant head of the engineering services group.

NORTHERN ALUMINIUM COMPANY, Ltd., Banbury, announces that Mr. C. P. Paton, general works manager, has been elected a director of the company.

MR. G. SENIOR is retiring from the office of joint managing director of Richard Sutcliffe, Ltd., Horbury. He has been in the company's service since 1912.

BRITISH TIMKEN, Ltd., states that Mr. F. E. Sheppard, B.Sc. (Eng.), A.M.I.Mech.E., has been appointed railway division sales engineer in the London area.

MR. A. C. HARTLEY, M.I.Mech.E., until recently chief engineer of the Anglo-Iranian Oil Company, Ltd., has been appointed to the board of Johnson and Phillips, Ltd.

THE MINISTER OF TRANSPORT has appointed Colonel Mark Whitwill, C.B.E., to be chairman of the Transport Users' Consultative Committee for the South-West area.

MR. R. G. WINTON, A.M.I.Mech.E., technical manager of Lansing Bagnall, Ltd., is representing the United Kingdom on the European materials handling mission to the U.S.A.

MATTERSON, Ltd., Rochdale, has appointed Mr. G. D. Clothier, B.Sc., A.M.I.E.E., Consett Chambers, 116, Pilgrim Street, Newcastle upon Tyne, as representative in the Northern Counties.

A. C. COSSOR, Ltd., states that Mr. L. L. Roberts, general manager of the company, and director and general manager of Cossor Radar, Ltd., has resigned from these posts to take up a position with Rootes, Ltd.

MR. W. J. CHALK, B.A., has joined the staff of the overseas and engineering information department of the B.B.C. to deal mainly with work concerned with the allocation of broadcasting wavelengths, and to take part in international and other conferences on this and related subjects.

GEORGE ADLAM AND SONS, Ltd., Bristol, announces that it has acquired a controlling interest in Scotts Engineering (Newport), Ltd., a firm of general engineers and manufacturers of dairy equipment. Scotts Engineering (Newport), Ltd., will continue to operate as a separate undertaking.

British Patent Specifications

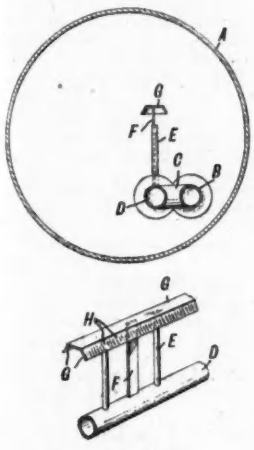
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

STEAM GENERATORS

651,458. February 28, 1947.—Boiler Feed Water Systems, The Anglo-Iranian Oil Company, Ltd., of Britannic House, Finsbury Circus, London, E.C.2, and Colin Langsford Beale, of Autumn Haze, Rewe, Exeter, the legal representative of Sydney Rupert Dight, Engineer Rear-Admiral, C.B.E., late of 3, Constable Close, London, N.W.11.

The invention is concerned with providing an improved method and means of delivering the feed water into the steam space of the boiler. According to the construction illustrated in the accompanying drawings, the feed water is passed into the boiler *A* through a main *B*, which extends horizontally along the length of the boiler and below the normal level of the water in the boiler. The main passes through the boiler and may be used to supply other boilers with feed water. The main is connected



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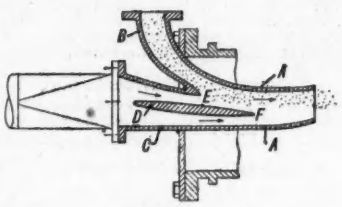
through a pipe *C* to a parallel feed pipe *D* mounted below the normal water level and closed at its ends. The feed pipe has spaced in it a number of vertical branch pipes *E* of smaller cross section, through which the feed water, passing through the main *B*, the pipe *C*, and the feed pipe *D*, is projected upward into the steam space in the boiler. Mounted on vertical supports *F* on the feed pipe *D* is a deflection plate, or a series of deflection plates *G*, of trapezoidal section. The longitudinal outward slanting walls of the deflection plates are corrugated to form on the inner face parallel grooves *H*, whereby the feed water discharged from the vertical branch pipes is deflected downward at an angle and discharged in a row of thin streams on each side of the vertical branch pipes and the feed pipe. The streams of feed water remove suspended particles of water from the steam in the boiler.—*April* 4, 1951.

FURNACES

651,490. May 28, 1948.—Burners for Use with Pulverised Fuel, Maria Justina van Tongeren-Boers, of 32-34, Johannes Verhulstlaan, Heemstede, The Netherlands.

The object of the invention is to provide a burner which gives a complete and uniform mixing of the fuel and air, and comprises means which prevent the fuel in the mixture from dropping by gravity before being conveyed into the furnace a sufficient distance to be completely burnt. The drawing illustrates a burner designed in accordance with the invention. *A* represents the more or less horizontal burner tube, *B* a fuel inlet opening obliquely into the top wall of the burner tube, for connection to the pulverised fuel supply pipe, and *C* an air inlet opening axially into the burner tube. Inside the burner tube, at a level about midway between the top and bottom thereof, is a deflector plate *D*. As will be seen, the deflector, together with the wall of the compressed air feed pipe *C*, and the wall of the fuel inlet opening *B*, constitutes a convergent-divergent throat or ejector. The fuel inlet *B* is curved so as to open obliquely into the tubular member *A*. Immediately at the rear of the opening is the throat *E* of a converging passage defined by the rear portion of the deflector *D* and the top wall of an air inlet *C*, which converging passage causes an acceleration of the air passing through it. In front of the opening is a diverging passage defined by the wall around the mouth of fuel inlet *B* and by that portion of the deflector which is beneath the mouth. In this diverging passage the velocity of the air is converted



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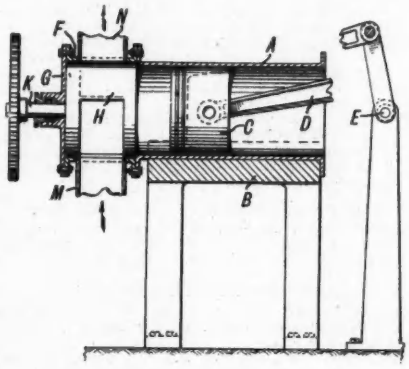
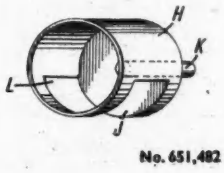
into pressure. The passage below the deflector converges towards the burner outlet, the throat *F* of which passage has substantially the same width as the throat *E*, and is located near the front edge of the deflector. By reason of this arrangement the velocity of the lower or carrier air current will exceed that of the upper current, which is retarded by the pulverised fuel suspended therein, This increases the carrying capacity of the lower current. The lower air current will still act as a carrier if the deflector *D* should be provided at a lower level than midway between the top and bottom of the tubular member—that is to say, if the strength of the upper current should exceed that of the lower current.—*April* 4, 1951.

PUMPS

651,482. February 29, 1948.—Reciprocating Pumps, The Humphrey's Railways Incorporated, Weems, Virginia, U.S.A.

This invention relates to pumps adapted to handle a mixture of pieces of solid material with a liquid, such as a mixture of fish and water. Referring to the drawings, the single-acting reciprocating pump comprises a cylinder *A*, open at the end, and mounted on a suitable support *B*. In the cylinder is a solid piston *C* coupled by means of a connecting-rod *D* to the crank of a crankshaft *E*. At the end of the cylinder, opposite its open end, is a valve housing or casing *F*, secured to the cylinder





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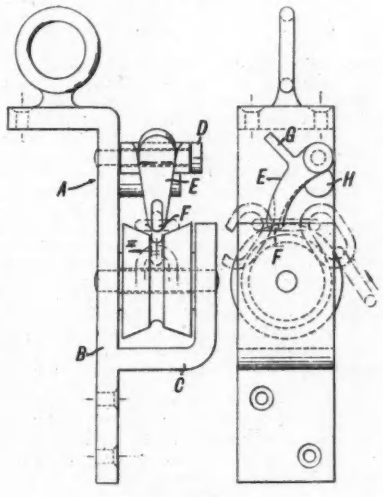
by flanges fastened together by bolts. A head *G* closes the outer end of the valve casing. The casing *F* is of slightly greater internal diameter than the cylinder, thus forming an annular shoulder at the joint between the cylinder and casing, for the purpose of maintaining in position a rotary valve *H* within the casing. This valve is a hollow cylindrical member, having one open end communicating with the interior of the cylinder and closed at its other end by a head *J*, in the centre of which is mounted a shaft *K*. The valve has a port L cut in the wall which extends almost half way around the valve. The two side edges of this port extend axially, and the trailing edge is sharpened to provide a knife edge. As shown in the drawing the head carries a stuffing-box through which the shaft extends, and to the outer end of the shaft a gear is secured which is driven from the crankshaft. Thus, as the piston reciprocates, the valve is rotated in synchronism with it or in definite timed relation. Projecting radially from the cylindrical valve casing *F* are intake and discharge conduits *M* and *N*. The inlet *M* is a pipe connection and to this may be attached a suction hose, the open end of which may be inserted into the fish hold of a boat, containing a mass of fish mixed with water. During the suction stroke of the piston the port *L* is in such a position that the end of the conduit *M* entering the valve casing *F* is open, and the mixture of fish and water can enter the valve and cylinder. At or just before the piston begins its return or delivery stroke, the port *L* reaches such position as to uncover the end of the discharge conduit, while, at the same time, the valve covers the end of the intake conduit. As the piston moves inwards, it forces the fish and water mixture contained in the cylinder out through the port and discharge conduit. By the fact that the valve is hollow, it provides a chamber within which any fish which were not discharged may be temporarily held as the piston approaches the innermost limit of its stroke, thus preventing the fish from being mashed by the piston. If, by chance, a fish should be caught within the mouth of the intake or discharge conduit, as the valve closes, the sharp knife edge of the valve cuts it off and prevents clogging or jamming.—*April* 4, 1951.

MARINE ENGINEERING

651,398. July 7, 1947.—Mooring Devices for Vessels such as Yachts, Commercial Boats, Ltd., of The Barge Walk, East Molesey, Surrey, and Alan Howard Lindley-Jones, of Flat 284, The White House, Albany Street, London, N.W.1.

This invention relates to mooring devices for vessels such as small boats and yachts, and is more particularly concerned with means for providing for the automatic holding against reverse motion of a chain, such as an anchor chain, during its adjustment. In the drawing a bracket member *A* comprises a flat portion *B* to one side of which is formed an offset L-shaped lug *C* adapted to provide a channel within which is located a roller for guiding the chain. The roller has a central groove of semi-circular cross section adapted to receive and guide one alternate set of the chain links, while the flanking surfaces on each side of such groove are of



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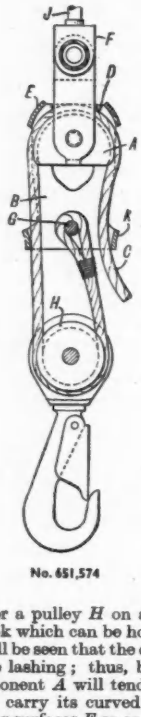
frusto-conical form disposed to provide a guiding surface of flattened V-section for the other alternate set of chain links. At its upper end, and to one side of the roller, the plate portion *B* has a riveted pivot pin *D* which receives a hinged pawl *E* having a projecting nose *F*. The pawl nose is shaped so as to enter into the aperture of any horizontally disposed chain link, while both its upper and lower surfaces are conveniently grooved to fit upon and co-operate with the chain links. The upper surface of the pawl member is provided with a projecting finger piece *G* to permit its being lifted manually clear of the chain when desired. Below the pivot pin is a projecting abutment *H* adapted to form a stop for the pawl, which engages in and arrests the chain against movement over the roller in one direction, while allowing free movement of the chain in the other. In the modified form shown in the specification, the plate portion and the L-shaped lug are merged into a base plate of circular shape, adapted for securing upon the deck planking of a vessel instead of upon the stem post.—*April* 4, 1951.

MISCELLANEOUS

651,574. July 7, 1948.—Cleats or Clamps for Ropes, Aerolex, Ltd., of Bridge Road, Camberley, Surrey, and Frank Bernard Harley, 1, Park Road, Camberley.

Referring to the drawing the cleat comprises two components *A*, *B*, which are arranged for connection in a lashing line which includes a rope *C*; one component *A* has a curved end surface *D*, about which the rope is taken. This component can slide on the second component *B*, which has at least one, and preferably as shown, two clamping surfaces *E* in opposition to the curved end surface *D*. The cleat is connected in a lashing arrangement by providing the component *A* with a shackle *F*, to which can be connected one end of a flexible rope which is passed over the article to be lashed and is anchored at its other end. In addition, the other component *B* is provided with a pin *G* to which one end of the rope *C* is connected, the rope then



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being passed over a pulley *H* on a frame having a quick-release hook which can be hooked to a second anchorage. It will be seen that the cleat is effectively interposed in the lashing; thus, by pulling on the rope *C* the component *A* will tend to move on the component *B* to carry its curved surface *D* away from the clamping surfaces *E* so as to allow the rope to pass freely; the effect of pulling on the rope is to shorten the loop passing over the pulley *H* and thus to shorten the length of the lashing, which, in turn, causes the lashing to tighten on to the article to be lashed. The lashing tension reacts to cause the parts *A* and *B* to tend to move on one another in the reverse direction so that as soon as the pull on the rope is released the surface *D* and the clamping surfaces are urged towards one another and so grip the rope firmly and prevent it from running out, or, in other words, to hold the lashing at the tension to which it had been pulled. The lashing tension can be increased beyond that which could be obtained by direct pull on the rope by providing in the lashing a turnbuckle *J*. The component *B* is preferably provided with guides *K* through or past which the rope, having been trained about the curved surface, is taken.—*April* 4, 1951.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Mon., April 30th.—Bournemouth Branch: Grand Hotel, Firvale Road, Bournemouth, "Storage Battery Applications," 8.15 p.m.

Chemical Society

Thurs., May 3rd.—Burlington House, Piccadilly, London, W.1, "Chemical Evidence Relative to the Origins of the Earth and Planets," H. C. Urey, 7.30 p.m.

Electric Railway Society

Thurs., May 3rd.—Fred Tallant Hall, Drummond Street, London, N.W.1, "Track Lay-out for Intensive Electric Services," G. T. Moody, 7.30 p.m.

Engineer Buyers' and Representatives' Association

Wed., May 2nd.—Works visit to Chance Brothers, Ltd., Glass Works, Smethwick, 2 p.m.

Engineers' Guild

Thurs., May 3rd.—Caxton Hall, Westminster, S.W.1, "How Engineers Can Promote International Understanding," C. W. Niel McGowan, 6 p.m.

Incorporated Plant Engineers

To-day, April 27th.—Birmingham Branch: Imperial Hotel, Temple Street, Birmingham, "Lifting Appliances: Their Use and Care," A. S. Wann, 7.30 p.m.

Mon., April 30th.—W. and E. Yorkshire Branch: The University, Leeds, "Tractors, Excavators and Civil Engineering Plant," H. Leverton, 7.30 p.m.

Institute of British Foundrymen

Sat., April 28th.—W. Riding of Yorks Branch: Technical College, Bradford, annual general meeting, followed by S. W. Wise, prize-winning paper, 6.30 p.m.

Institute of Economic Engineering

Fri., May 4th.—Manchester Branch: Engineers' Club, Albert Square, Manchester, Open Discussion, 7.30 p.m.

Institute of Industrial Supervisors

To-day, April 27th.—Cardiff Section: Technical College, Cardiff, "Attitude," J. Twomey, 7 p.m.

Thurs., May 3rd.—Warrington Section: White Hart Hotel, Sankey Street, Warrington, "Plan for Training in Industry," L. S. Newton, 7 p.m.——Leeds Section: College of Commerce, Leeds, "Incentives," C. W. Mustill, 7.30 p.m.

Institute of Road Transport Engineers

Fri., May 4th.—E. Midlands Centre: Miltons Head Hotel, Nottingham, Annual General Meeting and Dinner, 6.30 p.m.

Institution of Civil Engineers

To-day, April 27th.—Yorkshire Association: Great Northern Station Hotel, Leeds, annual general meeting, 7 p.m.; students' annual general meeting, 6.45 p.m.; followed by "Civil Engineering and Medicine in the Field of Environmental Health," N. R. Beattie, 7 p.m.

Tues., May 1st.—Great George Street, Westminster, S.W.1, "The Design and Construction of the Baghdad Railway and Road Bridge," A. E. Reid and F. W. Sully, 5.30 p.m.

Fri., May 4th.—N.W. Association: Engineers' Club, Albert Square, Manchester, Annual General Meeting, "Impressions of a Tour of the U.S.A. with the British Opencast Coal Mission," A. Monk, 6.30 p.m.

Institution of Electrical Engineers

To-day, April 27th.—Scottish Centre: Central Hall, Edinburgh, "Illumination," J. L. Davies, 7 p.m.

Mon., April 30th.—London Students' Section: Savoy Place, Victoria Embankment, W.C.2, Address by the President, Sir Archibald J. Gill, 7 p.m.

Tues., May 1st.—Measurements Section: Savoy Place, Victoria Embankment, W.C.2, "The Measurement of Natural Frequencies of Power Networks," P. Fourmarier, 5.30 p.m.——S. Midland Centre: Works Institute, Hylton Road Power Station, Worcester, Discussion on "Engineering: Financial Problems Arising in the Electricity Supply Industry," D. H. Kendon, 7 p.m.

Thurs., May 3rd.—Utilization Section: Savoy Place, Victoria Embankment, W.C.2, "A New Power Stroboscope for High-Speed Flash Photography," W. D. Chesterman, D. R. Glegg, G. T. Peck and A. J. Meadowcroft, 5.30 p.m.

Institution of Heating and Ventilating Engineers

To-day, April 27th.—Manchester and District Branch: Town Hall, Manchester, "Ventilation and Heating of Laboratories," H. Coase, 6.30 p.m.

Institution of Mechanical Engineers

To-day, April 27th.—Storey's Gate, St. James's Park, S.W.1, discussion on "The New Factory," J. G. Bulger, 5.30 p.m.

Mon., April 30th.—Derby A.D. Centre: Midland Hotel, Derby, "Prospects of the Gas Turbine Car," Geoffrey Smith, 7.15 p.m.

Wed., May 2nd.—Graduates' Section: Storey's Gate, St. James's Park, S.W.1, Annual General Meeting, "Some Aspects of Torsional Vibration of High-Speed, Light-Weight, Vehicle-Type Oil Engines," G. Brown, 6.30 p.m.

Fri., May 4th.—Storey's Gate, St. James's Park, S.W.1, "Stages in the Design of the Large Burmeister and Wain Marine Diesel Engine," H. H. Blache, 5.30 p.m.

Institution of Production Engineers

Wed., May 2nd.—Nottingham Section: Victoria Station Hotel, Milton Street, Nottingham, Discussion among five members of Productivity Teams, 7 p.m.

Institution of Sanitary Engineers

Thurs., May 3rd.—Caxton Hall, Westminster, S.W.1, Discussion on "Civil Engineering Code of Practice No. 5, 'Drainage (Sewerage),'" opened by F. J. Crabb, 6 p.m.

Institution of Structural Engineers

To-day, April 27th.—Midlands Counties Branch: James Watt Memorial Institute, Great Charles Street, Birmingham, annual general meeting, 6 p.m.

Tues., May 1st.—Wales and Monmouthshire Branch: Mackworth Hotel, Swansea, Annual General Meeting, 6.30 p.m.

Junior Institution of Engineers

Wed., May 2nd.—Midland Section: James Watt Memorial Institute, Great Charles Street, Birmingham, "What is Coal?" Stacey G. Ward, 7 p.m.

Society of Engineers

To-day, April 27th.—17, Victoria Street, Westminster, S.W.1, "Some Notes on Domestic Science," F. W. Davies, 6.30 p.m.

Launches and Trial Trips

Credo, motor tanker; built by Vickers-Armstrongs, Ltd., for A/S Jensens Rederi II; length between perpendiculars 565ft, breadth moulded 80ft, depth moulded 42ft 6½in, deadweight 25,150 tons on 32ft 6½in summer draught; eleven triple tanks, two pump rooms, with four 500 tons per hour horizontal duplex cargo oil pumps, steam deck machinery; Vickers-Doxford oil engine, six cylinders, 670mm diameter by 2320mm combined stroke, 6600 b.h.p. at 115 r.p.m., two cylindrical Scotch boilers; speed 13½ knots. Trial, March.

Singapore, cargo liner; built by John Brown and Co., Ltd., for the Peninsular and Oriental Steam Navigation Company; length 525ft, breadth 70ft, 10,750 tons deadweight on 29ft 6in draught; five holds, "Drihold" ventilation, twelve passengers; one set of geared turbines, 13,000 s.h.p., service speed 18 knots. Trial, April 10th.

Oredal, motor tanker; built by Harland and Wolff, Ltd., for Moltzan and Christensen, Oslo; length between perpendiculars 460ft, breadth moulded 59ft, depth moulded 34ft 10in, deadweight 12,000 tons, 24 cargo oil tanks, two pump rooms, steam deck machinery; Harland-Burmeister and Wain single-acting, four-stroke, diesel engine, six cylinders, 740mm diameter by 1500mm stroke, 115 r.p.m., two single-ended multi-tubular boilers. Trial, April 17th.

Hewitt, motor tug; built by Henry Robb, Ltd., for the Ribble Navigation and Preston Docks Board; length overall 92ft, breadth moulded 23ft, depth moulded 11ft 6in, mean draught 9ft. Two sets of two-cycle Crossley diesel engines, six cylinders, total brake horsepower 800 at 300 r.p.m. Launch, April 24th.

Contracts

Walker Brothers (Wigan), Ltd., has received from the Zinc Corporation, Ltd., Australia, an order for ventilation plant for the Broken Hill mines. The fan, which will be 209in diameter of single-stage design, will be handling a maximum quantity of 900,000 cubic feet per minute at approximately 4·0in water gauge.

Vickers-Armstrongs, Ltd., are to build for Furness, Withy and Co., Ltd., a passenger and cargo ship of 9300 gross tons. The vessel will have a length between perpendiculars of 470ft by 63ft 2in beam, and a service speed of 15½ knots, and single-reduction geared turbine machinery of 7700 s.h.p., built by Parsons Marine Steam Turbine Company, Ltd.

Summer School in Relaxation Methods, September, 1951.—In the long vacation of the years 1945–50 summer schools in Relaxation Methods were held at Imperial College, and in 1949–50 also in U.S.A. Their success has encouraged the provision of similar courses in both England and U.S.A. in the coming long vacation; that at Imperial College is now planned for the three weeks September 3 to 21, 1951. It will cover the numerical solution of linear algebraic equations, framework problems, Laplace's and Poisson's equations, the biharmonic equation, eigenvalue problems, the heat-conduction equation, &c. The course will consist of daily lectures in the mornings beginning at 10.15 a.m. with numerous practical examples to be solved under supervision in the afternoons. The fee for the course will be £10, and further particulars can be obtained from D. N. de G. Allen, Imperial College, London, S.W.7.

D.S.I.R. Research Boards.—The Department of Scientific and Industrial Research announces the following appointments to its Research Boards: Building Research, Sir Luke Fawcett, Mr. H. J. B. Harding, M.I.C.E., Mr. L. C. Howitt and Miss J. Lederboer; Chemistry Research, Professor R. D. Haworth, F.R.S., and Mr. R. M. Winter, F.R.I.C.; Fire Research, Sir George Burt, M.I.C.E., and Mr. A. B. Hunter; Forest Products Research, Professor W. T. Astbury, Sc.D., and Mr. David Booth; Fuel Research, Professor T. R. C. Fox and Professor J. Small; Hydraulics Research, Mr. A. C. Hartley, M.I.C.E., M.I.Mech.E., and Mr. W. K. Wallace, M.I.C.E.; Radio Research, Mr. C. E. Strong, M.I.E.E.; Water Pollution Research, Professor D. M. Newitt, F.R.S., Mr. H. W. Harvey, F.R.S., and Mr. S. H. Jenkins, F.R.I.C. Most of these appointments are for four years, the members serving on the Research Boards as individuals and not as representatives of any organisation to which they may belong.